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(54) Title: HETEROCYCLIC AMIDE DERIVATIVES WHICH POSSES GLYCOGEN PHOSPHORYLASE INHIBITORY ACTIVITY

(57) Abstract: A compound of the formula (1) or a pharmaceutically-acceptable salt thereof wherein: R⁴ and R⁵ together are either -S-C(R⁶)=C(R⁷)- or -C(R⁷)=C(R⁶)-S-; A is phenylene or heteroarylene; R¹ is for example selected from halo, nitro, cyano, hydroxy, carboxy, carbamoyl, N-(1-4C)alkylcarbamoyl, N-(1-4C)alkylsulphamoyl, (1-4C)alkyl, (1-4C)alkoxy, (1-4C)alkanoyl, (1-4C)alkanoyloxy, hydroxy(1-4C)alkyl, fluoromethyl, and -NHSO₂(1-4C)alkyl; or, when n is 2, the two R¹ groups, together with the carbon atoms of A to which they are attached, may form a 4 to 7 membered saturated ring, optionally containing 1 or 2 heteroatoms independently selected from O, S and N; R² and R³ together with the nitrogen to which they are attached form an optionally substituted 4- to 7-membered, heterocyclic ring; possess glycogen phosphorylase inhibitory activity and accordingly have value in the treatment of disease states associated with increased glycogen phosphorylase activity. Processes for the manufacture of compounds and pharmaceutical compositions containing them are described.

HETEROCYCLIC AMID DERIVATIVES WHICH POSSESS GLYCOGEN PHOSPHORYLASE INHIBITORY ACTIVITY

The present invention relates to heterocyclic amide derivatives, pharmaceutically acceptable salts and in-vivo hydrolysable esters thereof. These heterocyclic amides possess 5 glycogen phosphorylase inhibitory activity and accordingly have value in the treatment of disease states associated with increased glycogen phosphorylase activity and thus are potentially useful in methods of treatment of a warm-blooded animal such as man. The invention also relates to processes for the manufacture of said heterocyclic amide derivatives, to pharmaceutical compositions containing them and to their use in the manufacture of 10 medicaments to inhibit glycogen phosphorylase activity in a warm-blooded animal such as man.

The liver is the major organ regulating glycaemia in the post-absorptive state. Additionally, although having a smaller role in the contribution to post-prandial blood glucose levels, the response of the liver to exogenous sources of plasma glucose is key to an ability to 15 maintain euglycaemia. An increased hepatic glucose output (HGO) is considered to play an important role in maintaining the elevated fasting plasma glucose (FPG) levels seen in type 2 diabetics; particularly those with a FPG >140mg/dl (7.8mM). (Weyer et al, (1999), J Clin Invest 104: 787-794; Clore & Blackgard (1994), Diabetes 43: 256-262; De Fronzo, R. A., et al, (1992) Diabetes Care 15; 318 - 355; Reaven, G.M. (1995) Diabetologia 38; 3-13).

20 Since current oral, anti-diabetic therapies fail to bring FPG levels to within the normal, non-diabetic range and since raised FPG (and glycHbA1c) levels are risk factors for both macro- (Charles, M.A. et al (1996) Lancet 348, 1657-1658; Coutinho, M. et al (1999) Diabetes Care 22; 233-240; Shaw, J.E. et al (2000) Diabetes Care 23, 34-39) and micro-vascular disease (DCCT Research Group (1993) New. Eng. J. Med. 329; 977-986); the 25 reduction and normalisation of elevated FPG levels remains a treatment goal in type 2 DM.

It has been estimated that, after an overnight fast, 74% of HGO was derived from glycogenolysis with the remainder derived from gluconeogenic precursors (Hellerstein et al 30 (1997) Am J Physiol, 272: E163). Glycogen phosphorylase is a key enzyme in the generation by glycogenolysis of glucose-1-phosphate, and hence glucose in liver and also in other tissues such as muscle and neuronal tissue.

Liver glycogen phosphorylase activity is elevated in diabetic animal models including the db/db mouse and the fa/fa rat (Aiston S et al (2000). Diabetologia 43, 589-597).

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Inhibition of hepatic glycogen phosphorylase with chloroindole inhibitors (CP91149 and CP320626) has been shown to reduce both glucagon stimulated glycogenolysis and glucose output in hepatocytes (Hoover et al (1998) J Med Chem 41, 2934-8; Martin et al (1998) PNAS 95, 1776-81). Additionally, plasma glucose concentration is reduced, in a dose related manner, db/db and ob/ob mice following treatment with these compounds.

Studies in conscious dogs with glucagon challenge in the absence and presence of another glycogen phosphorylase inhibitor, Bay K 3401, also show the potential utility of such agents where there is elevated circulating levels of glucagon, as in both Type 1 and Type 2 diabetes. In the presence of Bay R 3401, hepatic glucose output and arterial plasma glucose following a glucagon challenge were reduced significantly (Shiota et al, (1997), Am J Physiol, 273: E868).

The heterocyclic amides of the present invention possess glycogen phosphorylase inhibitory activity and accordingly are expected to be of use in the treatment of type 2 diabetes, insulin resistance, syndrome X, hyperinsulinaemia, hyperglucagonaemia, cardiac ischaemia and obesity, particularly type 2 diabetes.

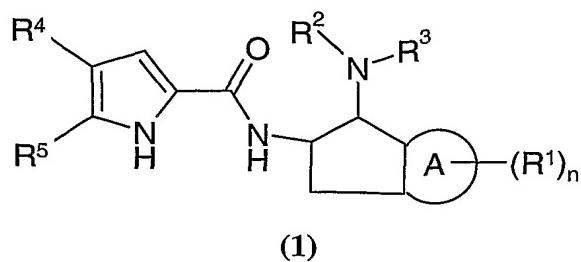
Our patent application WO 02/20530 discloses a spectrum of active glycogen phosphorylase inhibitors, amongst which are a very limited number of amino-indan containing compounds.

Our co-pending patent applications PCT/GB03/00883 and PCT/GB03/00875 disclose a variety of substituted amino-indan glycogen phosphorylase inhibitors, generally containing only one substituent on the nitrogen of the amino-indan moiety, although a number are disubstituted and contain an N-acetyl group as one substituent.

Surprisingly, we have found that a group of N-linked heterocycle substituted amino-indans have improved physical properties (for example solubility, plasma-protein binding) and/or improved pharmacokinetic properties and/or demonstrate greater pharmacological selectivity in comparison with those of the compounds previously disclosed, which are particularly beneficial for a pharmaceutical.

According to one aspect of the present invention there is provided a compound of formula (1):

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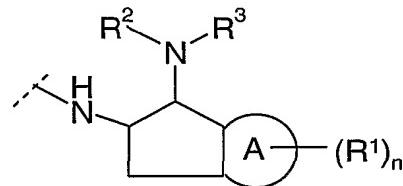


wherein:

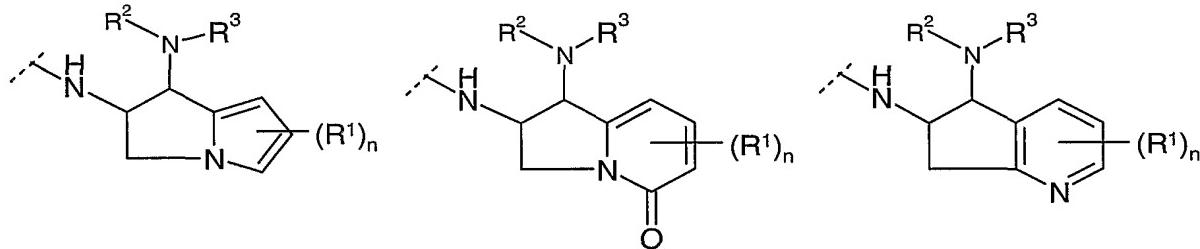
- R^4 and R^5 together are either $-S-C(R^6)=C(R^7)-$ or $-C(R^7)=C(R^6)-S-$;
- 5 R^6 and R^7 are independently selected from hydrogen, halo, nitro, cyano, hydroxy, fluoromethyl, difluoromethyl, trifluoromethyl, trifluoromethoxy, carboxy, carbamoyl, (1-4C)alkyl, (2-4C)alkenyl, (2-4C)alkynyl, (1-4C)alkoxy and (1-4C)alkanoyl;
- A is phenylene or heteroarylene;
- n is 0, 1 or 2;
- 10 R^1 is independently selected from halo, nitro, cyano, hydroxy, carboxy, carbamoyl, N -(1-4C)alkylcarbamoyl, N,N -((1-4C)alkyl)₂carbamoyl, sulphamoyl, N -(1-4C)alkylsulphamoyl, N,N -((1-4C)alkyl)₂sulphamoyl, $-S(O)_b$ (1-4C)alkyl (wherein b is 0,1,or 2), $-OS(O)_2$ (1-4C)alkyl, (1-4C)alkyl, (2-4C)alkenyl, (2-4C)alkynyl, (1-4C)alkoxy, (1-4C)alkanoyl, (1-4C)alkanoyloxy, hydroxy(1-4C)alkyl, fluoromethyl, difluoromethyl, trifluoromethyl, trifluoromethoxy and $-NHSO_2$ (1-4C)alkyl;
- 15 or, when n is 2, the two R^1 groups, together with the carbon atoms of A to which they are attached, may form a 4 to 7 membered saturated ring, optionally containing 1 or 2 heteroatoms independently selected from O, S and N, and optionally being substituted by one or two methyl groups;
- 20 R^2 and R^3 together with the nitrogen to which they are attached form a 4- to 7-membered, saturated, partially unsaturated or unsaturated heterocyclic ring optionally containing 1, 2 or 3 further heteroatoms independently selected from O, N and S (provided that there are no O-O, O-S or S-S bonds), wherein any N, S or C atom may optionally be oxidised, and wherein said heterocyclic ring is optionally substituted with 1 or 2 substituents independently selected from
- 25 halo, nitro, cyano, hydroxy, fluoromethyl, difluoromethyl, trifluoromethyl, trifluoromethoxy, carboxy, carbamoyl, (1-4C)alkyl, (2-4C)alkenyl, (2-4C)alkynyl, (1-4C)alkoxy, (1-4C)alkanoyl, -(1-4C)alkyl $S(O)_b$ (1-4C)alkyl (wherein b is 1 or 2), hydroxy(1-4C)alkyl, dihydroxy(2-4C)alkyl, amino(1-4C)alkyl, and imidazolylmethyl.
- or a pharmaceutically acceptable salt or pro-drug thereof.

In another aspect of the invention, there is provided a compound of formula (1) as hereinbefore defined, or a pharmaceutically acceptable salt or pro-drug thereof, wherein the ring comprising R² and R³ together with the nitrogen to which they are attached is optionally substituted with 1 or 2 substituents independently selected from halo, nitro, cyano, hydroxy, 5 fluoromethyl, difluoromethyl, trifluoromethyl, trifluoromethoxy, carboxy, carbamoyl, (1-4C)alkyl, (2-4C)alkenyl, (2-4C)alkynyl, (1-4C)alkoxy, (1-4C)alkanoyl, hydroxy(1-4C)alkyl, dihydroxy(2-4C)alkyl, amino(1-4C)alkyl, (1-4C)alkylNH(1-4C)alkyl-, and di[(1-4C)alkyl]N(1-4C)alkyl-.

It is to be understood that when A is heteroarylene, the bridgehead atoms joining ring A to 10 the ring may be heteroatoms. Therefore, for example, the definition of



when A is heteroarylene encompasses the structures:



It is to be understood that where substituents contain two substituents on an alkyl 15 chain, in which both are linked by a heteroatom (for example two alkoxy substituents), then these two substituents are not substituents on the same carbon atom of the alkyl chain.

In another aspect, the invention relates to compounds of formula (1) as hereinabove defined or to a pharmaceutically acceptable salt.

In another aspect, the invention relates to compounds of formula (1) as hereinabove 20 defined or to a pro-drug thereof. Suitable examples of pro-drugs of compounds of formula (1) are in-vivo hydrolysable esters of compounds of formula (1). Therefore in another aspect, the invention relates to compounds of formula (1) as hereinabove defined or to an in-vivo hydrolysable ester thereof.

It is to be understood that, insofar as certain of the compounds of formula (1) defined 25 above may exist in optically active or racemic forms by virtue of one or more asymmetric carbon atoms, the invention includes in its definition any such optically active or racemic

form which possesses glycogen phosphorylase inhibition activity. The synthesis of optically active forms may be carried out by standard techniques of organic chemistry well known in the art, for example by synthesis from optically active starting materials or by resolution of a racemic form. Similarly, the above-mentioned activity may be evaluated using the standard 5 laboratory techniques referred to hereinafter.

Within the present invention it is to be understood that a compound of the formula (1) or a salt thereof may exhibit the phenomenon of tautomerism and that the formulae drawings within this specification can represent only one of the possible tautomeric forms. It is to be understood that the invention encompasses any tautomeric form which has glycogen 10 phosphorylase inhibition activity and is not to be limited merely to any one tautomeric form utilised within the formulae drawings. The formulae drawings within this specification can represent only one of the possible tautomeric forms and it is to be understood that the specification encompasses all possible tautomeric forms of the compounds drawn not just those forms which it has been possible to show graphically herein.

15 It is also to be understood that certain compounds of the formula (1) and salts thereof can exist in solvated as well as unsolvated forms such as, for example, hydrated forms. It is to be understood that the invention encompasses all such solvated forms which have glycogen phosphorylase inhibition activity.

It is also to be understood that certain compounds of the formula (1) may exhibit 20 polymorphism, and that the invention encompasses all such forms which possess glycogen phosphorylase inhibition activity.

The present invention relates to the compounds of formula (1) as hereinbefore defined as well as to the salts thereof. Salts for use in pharmaceutical compositions will be pharmaceutically acceptable salts, but other salts may be useful in the production of the 25 compounds of formula (1) and their pharmaceutically acceptable salts. Pharmaceutically acceptable salts of the invention may, for example, include acid addition salts of the compounds of formula (1) as hereinbefore defined which are sufficiently basic to form such salts. Such acid addition salts include for example salts with inorganic or organic acids affording pharmaceutically acceptable anions such as with hydrogen halides (especially 30 hydrochloric or hydrobromic acid of which hydrochloric acid is particularly preferred) or with sulphuric or phosphoric acid, or with trifluoroacetic, citric or maleic acid. Suitable salts include hydrochlorides, hydrobromides, phosphates, sulphates, hydrogen sulphates, alkylsulphonates, arylsulphonates, acetates, benzoates, citrates, maleates, fumarates,

succinates, lactates and tartrates. In addition where the compounds of formula (1) are sufficiently acidic, pharmaceutically acceptable salts may be formed with an inorganic or organic base which affords a pharmaceutically acceptable cation. Such salts with inorganic or organic bases include for example an alkali metal salt, such as a sodium or potassium salt, an
5 alkaline earth metal salt such as a calcium or magnesium salt, an ammonium salt or for example a salt with methylamine, dimethylamine, trimethylamine, piperidine, morpholine or tris-(2-hydroxyethyl)amine.

The compounds of the invention may be administered in the form of a pro-drug which is broken down in the human or animal body to give a compound of the invention. A prodrug
10 may be used to alter or improve the physical and/or pharmacokinetic profile of the parent compound and can be formed when the parent compound contains a suitable group or substituent which can be derivatised to form a prodrug. Examples of pro-drugs include in-vivo hydrolysable esters of a compound of the invention or a pharmaceutically-acceptable salt thereof.

15 Various forms of prodrugs are known in the art, for examples see:

- a) Design of Prodrugs, edited by H. Bundgaard, (Elsevier, 1985) and Methods in Enzymology, Vol. 42, p. 309-396, edited by K. Widder, *et al.* (Academic Press, 1985);
- b) A Textbook of Drug Design and Development, edited by Krosgaard-Larsen and H. Bundgaard, Chapter 5 "Design and Application of Prodrugs", by H. Bundgaard p. 113-191
20 (1991);
- c) H. Bundgaard, Advanced Drug Delivery Reviews, 8, 1-38 (1992);
- d) H. Bundgaard, *et al.*, Journal of Pharmaceutical Sciences, 77, 285 (1988); and
- e) N. Kakeya, *et al.*, Chem Pharm Bull, 32, 692 (1984).

25 An in-vivo hydrolysable ester of a compound of formula (1) containing carboxy or hydroxy group is, for example, a pharmaceutically acceptable ester which is cleaved in the human or animal body to produce the parent acid or alcohol.

Suitable pharmaceutically acceptable esters for carboxy include alkyl esters, (1-6C)alkoxymethyl esters for example methoxymethyl, (1-6C)alkanoyloxymethyl esters for
30 example pivaloyloxymethyl, phthalidyl esters, (3-8C)cycloalkoxycarbonyloxy(1-6C)alkyl esters for example 1-cyclohexylcarbonyloxyethyl; 1,3-dioxolen-2-onylmethyl esters for example 5-methyl-1,3-dioxolen-2-onylmethyl; and (1-6C)alkoxycarbonyloxyethyl esters for

example 1-methoxycarbonyloxyethyl and may be formed at any carboxy group in the compounds of this invention.

Suitable pharmaceutically-acceptable esters for hydroxy include inorganic esters such as phosphate esters (including phosphoramidic cyclic esters) and α -acyloxyalkyl ethers and related compounds which as a result of the *in-vivo* hydrolysis of the ester breakdown to give the parent hydroxy group/s. Examples of α -acyloxyalkyl ethers include acetoxymethoxy and 2,2-dimethylpropionyloxymethoxy. A selection of *in-vivo* hydrolysable ester forming groups for hydroxy include (1-10C)alkanoyl, for example acetyl; benzoyl; phenylacetyl; substituted benzoyl and phenylacetyl, (1-10C)alkoxycarbonyl (to give alkyl carbonate esters), for example ethoxycarbonyl; di-((1-4C))alkylcarbamoyl and *N*-(di-((1-4C))alkylaminoethyl)-*N*-(1-4C)alkylcarbamoyl (to give carbamates); di-((1-4C))alkylaminoacetyl and carboxyacetyl. Examples of ring substituents on phenylacetyl and benzoyl include aminomethyl, ((1-4C))alkylaminomethyl and di-(((1-4C))alkyl)aminomethyl, and morpholino or piperazino linked from a ring nitrogen atom via a methylene linking group to the 3- or 4- position of the benzoyl ring. Other interesting *in-vivo* hyrolysable esters include, for example, $R^A C(O)O((1-6C))alkyl-CO-$, wherein R^A is for example, benzyloxy-((1-4C))alkyl, or phenyl). Suitable substituents on a phenyl group in such esters include, for example, 4-((1-4C))piperazino-((1-4C))alkyl, piperazino-((1-4C))alkyl and morpholino(1-4C)alkyl.

In this specification the generic term “alkyl” includes both straight-chain and branched-chain alkyl groups. However references to individual alkyl groups such as “propyl” are specific for the straight chain version only and references to individual branched-chain alkyl groups such as *t*-butyl are specific for the branched chain version only. For example, “(1-4C)alkyl” includes methyl, ethyl, propyl, isopropyl and *t*-butyl and examples of “(1-6C)alkyl” include the examples of “(1-4C)alkyl” and additionally pentyl, 2,3-dimethylpropyl, 3-methylbutyl and hexyl. An analogous convention applies to other generic terms, for example “(2-4C)alkenyl” includes vinyl, allyl and 1-propenyl and examples of “(2-6C)alkenyl” include the examples of “(2-4C)alkenyl” and additionally 1-but enyl, 2-but enyl, 3-but enyl, 2-methylbut-2-enyl, 3-methylbut-1-enyl, 1-pentenyl, 3-pentenyl and 4-hexenyl. Examples of “(2-4C)alkynyl” includes ethynyl, 1-propynyl and 2-propynyl and examples of “(2-6C)alkynyl” include the examples of “(2-4C)alkynyl” and additionally 3-butynyl, 2-pentynyl and 1-methylpent-2-ynyl.

The term "hydroxy(1-4C)alkyl" includes hydroxymethyl, hydroxyethyl, hydroxypropyl, hydroxyisopropyl and hydroxybutyl. The term "hydroxy(1-4C)alkyl" also includes hydroxycyclopropyl and hydroxycyclobutyl. The term "hydroxyethyl" includes 1-hydroxyethyl and 2-hydroxyethyl. The term "hydroxypropyl" includes 1-hydroxypropyl, 2-hydroxypropyl and 3-hydroxypropyl and an analogous convention applies to terms such as hydroxybutyl. The term "dihydroxy(2-4C)alkyl" includes dihydroxyethyl, dihydroxypropyl, dihydroxyisopropyl and dihydroxybutyl. The term "dihydroxypropyl" includes 1,2-dihydroxypropyl, 2,3-dihydroxypropyl and 1,3-dihydroxypropyl. An analogous convention applies to terms such as dihydroxyisopropyl and dihydroxybutyl. The term dihydroxy(2-4C)alkyl is not intended to include structures which are geminally disubstituted and thereby unstable.

The term "halo" refers to fluoro, chloro, bromo and iodo. The term "dihalo(1-4C)alkyl" includes difluoromethyl and dichloromethyl. The term "trihalo(1-4C)alkyl" includes trifluoromethyl.

Examples of "(1-4C)alkoxy" include methoxy, ethoxy, propoxy and isopropoxy. Examples of "(1-6C)alkoxy" include the examples of "(1-4C)alkoxy" and additionally butyloxy, *t*-butyloxy, pentoxy and 1,2-(methyl)₂propoxy. Examples of "(1-4C)alkanoyl" include formyl, acetyl and propionyl. Examples of "(1-6C)alkanoyl" include the example of "(1-4C)alkanoyl" and additionally butanoyl, pentanoyl, hexanoyl and 1,2-(methyl)₂propionyl. Examples of "(1-4C)alkanoyloxy" are formyloxy, acetoxy and propionoxy. Examples of "(1-6C)alkanoyloxy" include the examples of "(1-4C)alkanoyloxy" and additionally butanoyloxy, pentanoyloxy, hexanoyloxy and 1,2-(methyl)₂propionyloxy. Examples of "N-((1-4C)alkyl)amino" include methylamino and ethylamino. Examples of "N-((1-6C)alkyl)amino" include the examples of "N-((1-4C)alkyl)amino" and additionally pentylamino, hexylamino and 3-methylbutylamino. Examples of "N,N-((1-4C)alkyl)₂amino" include *N*-*N*-(methyl)₂amino, *N*-*N*-(ethyl)₂amino and *N*-ethyl-*N*-methylamino. Examples of "N,N-((1-6C)alkyl)₂amino" include the example of "N,N-((1-4C)alkyl)₂amino" and additionally *N*-methyl-*N*-pentylamino and *N*,*N*-(pentyl)₂amino. Examples of "N-((1-4C)alkyl)carbamoyl" are methylcarbamoyl and ethylcarbamoyl. Examples of "N-((1-6C)alkyl)carbamoyl" are the examples of "N-((1-4C)alkyl)carbamoyl" and additionally pentylcarbamoyl, hexylcarbamoyl and 1,2-(methyl)₂propylcarbamoyl. Examples of "N,N-((1-4C)alkyl)₂carbamoyl" are *N*,*N*-(methyl)₂carbamoyl, *N*,*N*-(ethyl)₂carbamoyl and *N*-methyl-*N*-ethylcarbamoyl. Examples of "N,N-((1-6C)alkyl)₂carbamoyl" are the examples of "N,N-((1-4C)alkyl)₂carbamoyl" and

additionally *N,N*-(pentyl)₂carbamoyl, *N*-methyl-*N*-pentylcarbamoyl and *N*-ethyl-*N*-hexylcarbamoyl. Examples of “*N*-((1-4C)alkyl)sulphamoyl” are *N*-(methyl)sulphamoyl and *N*-(ethyl)sulphamoyl. Examples of “*N*-((1-6C)alkyl)sulphamoyl” are the examples of “*N*-((1-4C)alkyl)sulphamoyl” and additionally *N*-pentylsulphamoyl, *N*-hexylsulphamoyl and 1,2-

5 (methyl)₂propylsulphamoyl. Examples of “*N,N*-((1-4C)alkyl)₂sulphamoyl” are *N,N*-(methyl)₂sulphamoyl, *N,N*-(ethyl)₂sulphamoyl and *N*-(methyl)-*N*-(ethyl)sulphamoyl.

Examples of “*N,N*-((1-6C)alkyl)₂sulphamoyl” are the examples of “*N,N*-((1-4C)alkyl)₂sulphamoyl” and additionally *N,N*-(pentyl)₂sulphamoyl, *N*-methyl-*N*-pentylsulphamoyl and *N*-ethyl-*N*-hexylsulphamoyl. Examples of “-NHSO₂(1-4C)alkyl”

10 include methylsulfonylamino, ethylsulfonylamino, propylsulfonylamino, isopropylsulfonylamino and tert-butylsulfonylamino.

Examples of “cyano((1-4C)alkyl” are cyanomethyl, cyanoethyl and cyanopropyl.

Examples of “(5-7C)cycloalkyl” are cyclopentyl, cyclohexyl and cycloheptyl. Examples of “(3-8C)cycloalkyl” and “(3-7C)cycloalkyl” include “(5-7C)cycloalkyl”, cyclopropyl,

15 cyclobutyl and cyclooctyl. Examples of “(3-6C)cycloalkyl” include cyclopropyl, cyclobutyl, cyclopentyl and cyclohexyl. Examples of “(3-6C)cycloalkyl(1-4C)alkyl” include cyclopropylmethyl, cyclopropylethyl, cyclopropylpropyl, cyclobutylmethyl, cyclopentylmethyl and cyclohexylmethyl.

The term “amino(1-4C)alkyl” includes aminomethyl, aminoethyl, aminopropyl,

20 aminoisopropyl and aminobutyl. The term “aminoethyl” includes 1-aminoethyl and 2-aminoethyl. The term “aminopropyl” includes 1-aminopropyl, 2-aminopropyl and 3-aminopropyl and an analogous convention applies to terms such as aminoethyl and aminobutyl.

Examples of “(1-4C)alkoxy(1-4C)alkyl” include methoxymethyl, ethoxymethyl,

25 methoxyethyl, ethoxypropyl and propoxymethyl.

Examples of “-S(O)_b(1-4C)alkyl (wherein b is 0,1 or 2)” include methylthio, ethylthio, propylthio, methylsulphinyl, ethylsulphinyl, propanesulphinyl, mesyl, ethylsulphonyl, propylsulphonyl and isopropylsulphonyl.

Examples of “-(1-4C)alkylS(O)_b(1-4C)alkyl (wherein b is 1 or 2)” include

30 methylsulphinylmethyl, ethylsulphinylmethyl, propylsulphinylmethyl, mesylmethyl, ethylsulphonylmethyl, propylsulphonylmethyl and isopropylsulphonylmethyl.

Examples of “(1-6C)alkoxycarbonyl” include methoxycarbonyl, ethoxycarbonyl, *n*- and *t*-butoxycarbonyl.

Within this specification composite terms are used to describe groups comprising more than one functionality such as -(1-4C)alkylSO₂(1-4C)alkyl. Such terms are to be interpreted in accordance with the meaning which is understood by a person skilled in the art for each component part. For example -(1-4C)alkylSO₂(1-4C)alkyl includes

5 -methylsulphonylmethyl, -methylsulphonylethyl, -ethylsulphonylmethyl, and -propylsulphonylbutyl.

Where optional substituents are chosen from "0, 1, 2 or 3" groups it is to be understood that this definition includes all substituents being chosen from one of the specified groups or the substituents being chosen from two or more of the specified groups. An 10 analogous convention applies to substituents chosen from "0, 1 or 2" groups, "0 or 1" groups and "1 or 2" groups.

"Heteroarylene" is a diradical of a heteroaryl group. A heteroaryl group is an aryl, monocyclic ring containing 5 to 7 atoms of which 1, 2, 3 or 4 ring atoms are chosen from nitrogen, sulphur or oxygen. Examples of heteroarylene are oxazolylene, oxadiazolylene, 15 pyridylene, pyrimidinylene, imidazolylene, triazolylene, tetrazolylene, pyrazinylene, pyridazinylene, pyrrolylene, thienylene and furylene.

Suitable optional substituents for heteroaryl groups, unless otherwise defined, are 1, 2 or 3 substituents independently selected from halo, cyano, nitro, amino, hydroxy, (1-4C)alkyl, (1-4C)alkoxy, -S(O)_b(1-4C)alkyl (wherein b is 0, 1 or 2), N-((1-4C)alkyl)amino and N,N-((1-20 4C)alkyl)₂amino. Further suitable optional substituents for "heteroaryl" groups are 1, 2 or 3 substituents independently selected from fluoro, chloro, cyano, nitro, amino, methylamino, dimethylamino, hydroxy, methyl, ethyl, methoxy, methylthio, methylsulfinyl and methylsulfonyl.

25 Preferred values of A, R¹ to R⁷ and n are as follows. Such values may be used where appropriate with any of the definitions, claims, aspects or embodiments defined hereinbefore or hereinafter.

In one embodiment of the invention are provided compounds of formula (1), in an alternative embodiment are provided pharmaceutically-acceptable salts of compounds of 30 formula (1), in a further alternative embodiment are provided in-vivo hydrolysable esters of compounds of formula (1), and in a further alternative embodiment are provided pharmaceutically-acceptable salts of in-vivo hydrolysable esters of compounds of formula (1). In a further alternative embodiment are provided pro-drugs of compounds of formula (1) and

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in a still further alternative embodiment are provided pharmaceutically-acceptable salts of pro-drugs of compounds of formula (1).

In one aspect of the present invention there is provided a compound of formula (1) as depicted above wherein R⁴ and R⁵ are together -S-C(R⁶)=C(R⁷)-.

5 In another aspect of the invention R⁴ and R⁵ are together -C(R⁷)=C(R⁶)-S-.

In a further aspect of the invention, R⁶ and R⁷ are independently selected from hydrogen, halo or (1-6C)alkyl.

Preferably R⁶ and R⁷ are independently selected from hydrogen, chloro, bromo or methyl.

10 Particularly R⁶ and R⁷ are independently selected from hydrogen or chloro.

More particularly one of R⁶ and R⁷ is chloro.

In one embodiment, one of R⁶ and R⁷ is chloro and the other is hydrogen.

In another embodiment, both R⁶ and R⁷ are chloro.

In one aspect of the invention A is phenylene.

15 In another aspect of the invention A is heteroarylene.

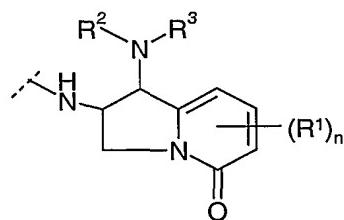
Suitable values for A are phenylene, pyridylene, pyrimidinylene, pyrrolylene, imidazolylene, triazolylene, tetrazolylene, oxazolylene, oxadiazolylene, thienylene and furylene.

Further suitable values for A are phenylene, pyridylene, pyrimidinylene, pyrrolylene 20 and imidazolylene.

Further suitable values for A are phenylene, pyridylene and pyrimidinylene.

Further suitable values for A are phenylene and pyridylene.

25 In one embodiment, when A is heteroarylene, there is a nitrogen in a bridgehead position. In another embodiment, when A is heteroarylene, the heteroatoms are not in bridgehead positions. It will be appreciated that the preferred (more stable) bridgehead position is as shown below:



In one aspect of the invention n is 0 or 1.

In one aspect preferably n is 1.

30 In another aspect, preferably n is 0.

When n is 2, and the two R¹ groups, together with the carbon atoms of A to which they are attached, form a 4 to 7 membered saturated ring, optionally containing 1 or 2 heteroatoms independently selected from O, S and N, conveniently such a ring is a 5 or 6 membered ring. In one embodiment, such a 5 or 6 membered ring contains two O atoms (ie a 5) cyclic acetal). When the two R¹ groups together form such a cyclic acetal, preferably it is not substituted. Most preferably the two R¹ groups together are the group -O-CH₂-O-.

In another aspect of the present invention R¹ is selected from halo, nitro, cyano, hydroxy, fluoromethyl, difluoromethyl, trifluoromethyl and (1-4C)alkoxy.

In a further aspect R¹ is selected from halo, nitro, cyano, hydroxy, fluoromethyl, difluoromethyl, trifluoromethyl, -S(O)_b(1-4C)alkyl (wherein b is 0, 1 or 2), -OS(O)₂(1-4C)alkyl, (1-4C)alkyl and (1-4C)alkoxy.

In a further aspect R¹ is selected from halo, nitro, cyano, hydroxy, fluoromethyl, difluoromethyl, trifluoromethyl, -S(O)_bMe (wherein b is 0, 1 or 2), -OS(O)₂Me, methyl and methoxy.

15 In a further aspect, R¹ is (1-4C)alkyl.

Preferably R¹ is selected from halo and (1-4C)alkoxy.

In another embodiment preferably R¹ is selected from fluoro, chloro, methyl, ethyl, methoxy and -O-CH₂-O-.

In one aspect of the invention R² and R³ together with the nitrogen to which they are attached form a 5- or 6-membered, saturated, partially unsaturated or unsaturated heterocyclic ring optionally containing 1, 2 or 3 further heteroatoms independently selected from O, N and S (provided that there are no O-O, O-S or S-S bonds), wherein any N, S or C atom may optionally be oxidised, and wherein said heterocyclic ring is optionally substituted with 1 or 2 substituents independently selected from halo, nitro, cyano, hydroxy, fluoromethyl, difluoromethyl, trifluoromethyl, trifluoromethoxy, carboxy, carbamoyl, (1-4C)alkyl, (2-4C)alkenyl, (2-4C)alkynyl, (1-4C)alkoxy, (1-4C)alkanoyl, hydroxy(1-4C)alkyl, dihydroxy(2-4C)alkyl, amino(1-4C)alkyl, (1-4C)alkylNH(1-4C)alkyl-, and di[(1-4C)alkyl]N(1-4C)alkyl-.

In another aspect of the invention, R² and R³ together with the nitrogen to which they are attached form a 5- or 6-membered, saturated, partially unsaturated or unsaturated heterocyclic ring optionally containing 1, 2 or 3 further heteroatoms independently selected from O, N and S (provided that there are no O-O, O-S or S-S bonds), wherein any N, S or C atom may optionally be oxidised, and wherein said heterocyclic ring is optionally substituted

with 1 or 2 substituents independently selected from halo, nitro, cyano, hydroxy, fluoromethyl, difluoromethyl, trifluoromethyl, trifluoromethoxy, carboxy, carbamoyl, (1-4C)alkyl, (2-4C)alkenyl, (2-4C)alkynyl, (1-4C)alkoxy, (1-4C)alkanoyl, -(1-4C)alkylS(O)_b(1-4C)alkyl (wherein b is 1 or 2), hydroxy(1-4C)alkyl, dihydroxy(2-4C)alkyl, amino(1-4C)alkyl, 5 and imidazolylmethyl.

In one aspect of the invention R² and R³ together with the nitrogen to which they are attached form a 4-membered ring as defined hereinbefore or hereinafter.

In another aspect of the invention R² and R³ together with the nitrogen to which they are attached form a 5-membered ring as defined hereinbefore or hereinafter.

10 In another aspect of the invention R² and R³ together with the nitrogen to which they are attached form a 6-membered ring as defined hereinbefore or hereinafter.

In another aspect of the invention R² and R³ together with the nitrogen to which they are attached form a 7-membered ring as defined hereinbefore or hereinafter.

15 In one aspect of the invention R² and R³ together with the nitrogen to which they are attached form a saturated ring.

In one aspect of the invention R² and R³ together with the nitrogen to which they are attached form a partially unsaturated ring.

In one aspect of the invention R² and R³ together with the nitrogen to which they are attached form a unsaturated ring.

20 In one aspect of the invention, invention R² and R³ together with the nitrogen to which they are attached form a ring containing a carbonyl group.

In another aspect of the invention, the ring formed by R² and R³ together with the nitrogen to which they are attached does not contain any further heteroatoms. An example of such a ring is 2-pyrrolidonyl.

25 In another aspect of the invention, the ring formed by R² and R³ together with the nitrogen to which they are attached contains one further heteroatom selected from O, N and S. An example of such a ring is 3-oxazolidinonyl.

Suitable values for a 4-7-membered ring comprising R²-N-R³ are morpholino, pyrrolyl, piperazinyl, triazolyl, tetrazolyl, imidazolyl, 3-oxazolidinonyl, thiomorpholino, 30 pyrrolinyl, homopiperazinyl, 3,5-dioxapiperidinyl, 3-oxopyrazolin-2-yl, pyrazolyl, pyrazolinyl, 4-oxopyridyl, 2-oxopyrrolidyl, 2-oxoazetidinyl, 1-oxidoisothiazolidinyl, 1-oxido-1,2-thiazinanyl, 1,1-dioxidoisothiazolidinyl, 1,1-dioxido-1,2-thiazinanyl, 2-oxopyrrolidinyl, 2-oxopiperidinyl, 2-oxoimidazolidinyl, 2-oxohexahydropyrimidinyl,

2-oxido-1,2,3-oxathiazolidinyl, 2,2-dioxido-1,2,3-oxathiazolidinyl,
2-oxido-1,2,3-oxathiazinanyl, 2,2-dioxido-1,2,3-oxathiazinanyl,
1-oxido-1,2,5-thiadiazolidinyl, 1,1-dioxido-1,2,5-thiadiazolidinyl,
1-oxido-1,2,6-thiadiazinanyl and 1,1-dioxido-1,2,6-thiadiazinanyl.

5 Suitable values for a 5- or 6-membered ring comprising R²-N-R³ are morpholino, pyrrolyl, piperazinyl, triazolyl, tetrazolyl, imidazolyl, 3-oxazolidinonyl, thiomorpholino, pyrrolinyl, 3,5-dioxapiperidinyl, 3-oxopyrazolin-2-yl, pyrazolyl, pyrazolinyl, 4-oxopyridyl, 2-oxopyrrolidyl, 1-oxidoisothiazolidinyl, 1-oxido-1,2-thiazinanyl, 1,1-dioxidoisothiazolidinyl, 1,1-dioxido-1,2-thiazinanyl, 2-oxopyrrolidinyl, 2-oxopiperidinyl, 2-oxoimidazolidinyl, 2-oxohexahydropyrimidinyl, 2-oxido-1,2,3-oxathiazolidinyl, 2,2-dioxido-1,2,3-oxathiazolidinyl, 2-oxido-1,2,3-oxathiazinanyl, 2,2-dioxido-1,2,3-oxathiazinanyl, 1-oxido-1,2,5-thiadiazolidinyl, 1,1-dioxido-1,2,5-thiadiazolidinyl, 1-oxido-1,2,6-thiadiazinanyl and 1,1-dioxido-1,2,6-thiadiazinanyl.

10 Further suitable values for the ring comprising R²-N-R³ are morpholino, piperazinyl, 3-oxazolidinonyl, thiomorpholino, homopiperazinyl, 3,5-dioxidopiperidinyl, 3-oxopyrazolin-2-yl, 4-oxopyridyl, 2-oxopyrrolidyl, 2-oxoazetidinyl, 1-oxidoisothiazolidinyl, 1-oxido-1,2-thiazinanyl, 1,1-dioxidoisothiazolidinyl, 1,1-dioxido-1,2-thiazinanyl, 2-oxopyrrolidinyl, 2-oxopiperidinyl, 2-oxoimidazolidinyl, 2-oxohexahydropyrimidinyl, 2-oxido-1,2,3-oxathiazolidinyl, 2,2-dioxido-1,2,3-oxathiazolidinyl, 2-oxido-1,2,3-oxathiazinanyl, 2,2-dioxido-1,2,3-oxathiazinanyl, 1-oxido-1,2,5-thiadiazolidinyl, 1,1-dioxido-1,2,5-thiadiazolidinyl, 1-oxido-1,2,6-thiadiazinanyl and 1,1-dioxido-1,2,6-thiadiazinanyl.

15 Further suitable values for the ring comprising R²-N-R³ are morpholino, piperazinyl, 3-oxazolidinonyl, thiomorpholino, 3,5-dioxidopiperidinyl, 3-oxopyrazolin-2-yl, 4-oxopyridyl, 2-oxopyrrolidyl, 1-oxidoisothiazolidinyl, 1-oxido-1,2-thiazinanyl, 1,1-dioxidoisothiazolidinyl, 1,1-dioxido-1,2-thiazinanyl, 2-oxopyrrolidinyl, 2-oxopiperidinyl, 2-oxoimidazolidinyl, 2-oxohexahydropyrimidinyl, 2-oxido-1,2,3-oxathiazolidinyl, 2,2-dioxido-1,2,3-oxathiazolidinyl, 2-oxido-1,2,3-oxathiazinanyl, 2,2-dioxido-1,2,3-oxathiazinanyl, 1-oxido-1,2,5-thiadiazolidinyl, 1,1-dioxido-1,2,5-thiadiazolidinyl, 1-oxido-1,2,6-thiadiazinanyl and 1,1-dioxido-1,2,6-thiadiazinanyl.

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Further suitable values for the ring comprising $R^2\text{-}N\text{-}R^3$ are morpholino, piperazinyl, 3-oxazolidinonyl, 3,5-dioxidopiperidinyl, 3-oxopyrazolin-2-yl, 4-oxopyridyl, 2-oxopyrrolidyl, 2-oxopyrrolidinyl, 2-oxopiperidinyl, 2-oxoimidazolidinyl and 2-oxohexahydropyrimidinyl.

- 5 Further suitable values for the ring comprising $R^2\text{-}N\text{-}R^3$ are thiomorpholino, 1-oxidoisothiazolidinyl, 1-oxido-1,2-thiazinanyl, 1,1-dioxidoisothiazolidinyl, 1,1-dioxido-1,2-thiazinanyl, 2-oxido-1,2,3-oxathiazolidinyl, 2,2-dioxido-1,2,3-oxathiazolidinyl, 2-oxido-1,2,3-oxathiazinanyl, 2,2-dioxido-1,2,3-oxathiazinanyl, 1-oxido-1,2,5-thiadiazolidinyl, 10 1,1-dioxido-1,2,5-thiadiazolidinyl, 1-oxido-1,2,6-thiadiazinanyl and 1,1-dioxido-1,2,6-thiadiazinanyl.

- 15 Further suitable values for the ring comprising $R^2\text{-}N\text{-}R^3$ are morpholino, piperazinyl, 3-oxazolidinonyl, thiomorpholino, 3,5-dioxidopiperidinyl, 2-oxopyrrolidyl, 1-oxidoisothiazolidinyl, 1,1-dioxidoisothiazolidinyl, 2-oxopiperidinyl, 2-oxohexahydropyrimidinyl, 2-oxido-1,2,3-oxathiazolidinyl, 2,2-dioxido-1,2,3-oxathiazolidinyl, 2-oxido-1,2,3-oxathiazinanyl, 2,2-dioxido-1,2,3-oxathiazinanyl, 1-oxido-1,2,5-thiadiazolidinyl, and 1,1-dioxido-1,2,5-thiadiazolidinyl.

- 20 Further suitable values for the ring comprising $R^2\text{-}N\text{-}R^3$ are 2-oxo-1,3-oxazolidin-3-yl (3-oxazolidinonyl) and 2-oxopyrrolidinyl.

- 25 Suitable values for the optional substituents for the ring comprising $R^2\text{-}N\text{-}R^3$ are 1 or 2 substituents independently selected from halo, cyano, fluoromethyl, difluoromethyl, trifluoromethyl, trifluoromethoxy, carboxy, (1-4C)alkyl, (1-4C)alkoxy, hydroxy(1-4C)alkyl, and dihydroxy(2-4C)alkyl.

- 30 Further suitable values for the optional substituents for the ring comprising $R^2\text{-}N\text{-}R^3$ are 1 or 2 substituents independently selected from halo, carboxy, (1-4C)alkyl, (1-4C)alkoxy, hydroxy(1-4C)alkyl, and dihydroxy(2-4C)alkyl.

- Further suitable values for the optional substituents for the ring comprising $R^2\text{-}N\text{-}R^3$ are 1 or 2 substituents independently selected from hydroxy, hydroxy(1-4C)alkyl, amino(1-4C)alkyl, imidazolyl, -(1-4C)alkylS(O)_b(1-4C)alkyl (wherein b is 1 or 2), halo, cyano, fluoromethyl, difluoromethyl, trifluoromethyl, trifluoromethoxy, carboxy, (1-4C)alkyl, (1-4C)alkoxy, and dihydroxy(2-4C)alkyl.

Further suitable values for the optional substituents for the ring comprising R²-N-R³ are 1 or 2 substituents independently selected from halo, carboxy, (1-4C)alkyl, (1-4C)alkoxy, hydroxy, amino(1-4C)alkyl, imidazolyl, -(1-4C)alkylS(O)_b(1-4C)alkyl (wherein b is 1 or 2), hydroxy(1-4C)alkyl, and dihydroxy(2-4C)alkyl.

Further suitable values for the optional substituents for the ring comprising R²-N-R³ are 1 or 2 substituents independently selected from hydroxy, hydroxy(1-4C)alkyl, amino(1-4C)alkyl, imidazolyl, and -(1-4C)alkylS(O)_b(1-4C)alkyl (wherein b is 1 or 2)

Further suitable values for the optional substituents for the ring comprising R²-N-R³ are 1 or 2 substituents independently selected from hydroxy, hydroxymethyl, aminomethyl, imidazolyl, methylsulfonylmethyl and methylsulfinylmethyl.

Further suitable values for the optional substituents for the ring comprising R²-N-R³ are 1 or 2 substituents independently selected from hydroxy and hydroxymethyl.

In one aspect, the ring comprising R²-N-R³ is substituted with one substituent selected from any of the suitable values for such substituents mentioned hereinbefore. In another aspect, the ring comprising R²-N-R³ is unsubstituted.

In one aspect of the invention is provided a compound of the formula (I) wherein A is phenylene; n is 0, 1 or 2; R⁴ and R⁵ are together -S-C(R⁶)=C(R⁷)- or -C(R⁷)=C(R⁶)-S-; R⁶ and R⁷ are independently selected from hydrogen, chloro, bromo and methyl; R¹ is selected from fluoro, chloro, methyl, ethyl, methoxy and -O-CH₂-O-; R² and R³ together with the nitrogen to which they are attached form a 5- or 6-membered, saturated, partially unsaturated or unsaturated heterocyclic ring optionally containing 1, 2 or 3 further heteroatoms independently selected from O, N and S (provided that there are no O-O, O-S or S-S bonds), wherein any N, S or C atom may optionally be oxidised, and wherein said heterocyclic ring is optionally substituted with 1 or 2 substituents independently selected from halo, nitro, cyano, hydroxy, fluoromethyl, difluoromethyl, trifluoromethyl, trifluoromethoxy, carboxy, carbamoyl, (1-4C)alkyl, (2-4C)alkenyl, (2-4C)alkynyl, (1-4C)alkoxy, (1-4C)alkanoyl, hydroxy(1-4C)alkyl, dihydroxy(2-4C)alkyl, amino(1-4C)alkyl, (1-4C)alkylNH(1-4C)alkyl-, and di[(1-4C)alkyl]N(1-4C)alkyl-; or a pharmaceutically acceptable salt or in-vivo hydrolysable ester thereof.

In one aspect of the invention is provided a compound of the formula (I) wherein

A is phenylene;

n is 0, 1 or 2;

R⁴ and R⁵ are together -S-C(R⁶)=C(R⁷)- or -C(R⁷)=C(R⁶)-S-;

R⁶ and R⁷ are independently selected from hydrogen, chloro, bromo and methyl;

5 R¹ is selected from fluoro, chloro, methyl, ethyl, methoxy and -O-CH₂-O-;

R² and R³ together with the nitrogen to which they are attached form a 5- or 6-membered, saturated, partially unsaturated or unsaturated heterocyclic ring optionally containing 1, 2 or 3 further heteroatoms independently selected from O, N and S (provided that there are no O-O, O-S or S-S bonds), wherein any N, S or C atom may optionally be oxidised, and wherein said heterocyclic ring is optionally substituted with 1 or 2 substituents independently selected from halo, nitro, cyano, hydroxy, fluoromethyl, difluoromethyl, trifluoromethyl, trifluoromethoxy, carboxy, carbamoyl, (1-4C)alkyl, (2-4C)alkenyl, (2-4C)alkynyl, (1-4C)alkoxy, (1-4C)alkanoyl, -(1-4C)alkylS(O)_b(1-4C)alkyl (wherein b is 1 or 2), hydroxy(1-4C)alkyl, dihydroxy(2-4C)alkyl, amino(1-4C)alkyl, and imidazolylmethyl;

15 or a pharmaceutically acceptable salt or in-vivo hydrolysable ester thereof.

In another aspect of the invention is provided a compound of the formula (I) wherein

A is heteroarylene;

n is 0, 1 or 2;

R⁴ and R⁵ are together -S-C(R⁶)=C(R⁷)- or -C(R⁷)=C(R⁶)-S-;

20 R⁶ and R⁷ are independently selected from hydrogen, chloro, bromo and methyl;

R¹ is selected from fluoro, chloro, methyl, ethyl, methoxy and -O-CH₂-O-;

R² and R³ together with the nitrogen to which they are attached form a 4- to 7-membered, saturated, partially unsaturated or unsaturated heterocyclic ring optionally containing 1, 2 or 3 further heteroatoms independently selected from O, N and S (provided that there are no O-O, O-S or S-S bonds), wherein any N, S or C atom may optionally be oxidised, and wherein said heterocyclic ring is optionally substituted with 1 or 2 substituents independently selected from halo, nitro, cyano, hydroxy, fluoromethyl, difluoromethyl, trifluoromethyl, trifluoromethoxy, carboxy, carbamoyl, (1-4C)alkyl,

(2-4C)alkenyl, (2-4C)alkynyl, (1-4C)alkoxy, (1-4C)alkanoyl, hydroxy(1-4C)alkyl,

30 dihydroxy(2-4C)alkyl, amino(1-4C)alkyl, (1-4C)alkylNH(1-4C)alkyl-, and

di[(1-4C)alkyl]N(1-4C)alkyl-;

or a pharmaceutically acceptable salt or in-vivo hydrolysable ester thereof.

In another aspect of the invention is provided a compound of the formula (I) wherein

A is heteroarylene;

n is 0, 1 or 2;

R⁴ and R⁵ are together $-S-C(R^6)=C(R^7)-$ or $-C(R^7)=C(R^6)-S-$;

R⁶ and R⁷ are independently selected from hydrogen, chloro, bromo and methyl;

5 R¹ is selected from fluoro, chloro, methyl, ethyl, methoxy and $-O-CH_2-O-$;

R² and R³ together with the nitrogen to which they are attached form a 4- to 7-membered, saturated, partially unsaturated or unsaturated heterocyclic ring optionally containing 1, 2 or 3 further heteroatoms independently selected from O, N and S (provided that there are no O-O, O-S or S-S bonds), wherein any N, S or C atom may optionally be oxidised, and wherein said heterocyclic ring is optionally substituted with 1 or 2 substituents independently selected from halo, nitro, cyano, hydroxy, fluoromethyl, difluoromethyl, trifluoromethyl, trifluoromethoxy, carboxy, carbamoyl, (1-4C)alkyl, (2-4C)alkenyl, (2-4C)alkynyl, (1-4C)alkoxy, (1-4C)alkanoyl, -(1-4C)alkylS(O)_b(1-4C)alkyl (wherein b is 1 or 2), hydroxy(1-4C)alkyl, dihydroxy(2-4C)alkyl, amino(1-4C)alkyl, and imidazolylmethyl;

10 15 or a pharmaceutically acceptable salt or in-vivo hydrolysable ester thereof.

In another aspect of the invention is provided a compound of the formula (I) wherein

A is phenylene;

n is 0, 1 or 2;

R⁴ and R⁵ are together $-S-C(R^6)=C(R^7)-$ or $-C(R^7)=C(R^6)-S-$;

20 R⁶ and R⁷ are independently selected from hydrogen, chloro, bromo and methyl;

R¹ is selected from fluoro, chloro, methyl, ethyl, methoxy and $-O-CH_2-O-$;

R² and R³ together with the nitrogen to which they are attached form a ring selected from morpholino, pyrrolyl, piperazinyl, triazolyl, tetrazolyl, imidazolyl, 3-oxazolidinonyl, thiomorpholino, pyrrolinyl, homopiperazinyl, 3,5-dioxapiperidinyl, 3-oxopyrazolin-2-yl,

25 pyrazolyl, pyrazolinyl, 4-oxopyridyl, 2-oxopyrrolidyl, 2-oxoazetidinyl,

1-oxidoisothiazolidinyl, 1-oxido-1,2-thiazinanyl, 1,1-dioxidoisothiazolidinyl,

1,1-dioxido-1,2-thiazinanyl, 2-oxopyrrolidinyl, 2-oxopiperidinyl, 2-oxoimidazolidinyl,

2-oxohexahdropyrimidinyl, 2-oxido-1,2,3-oxathiazolidinyl,

2,2-dioxido-1,2,3-oxathiazolidinyl, 2-oxido-1,2,3-oxathiazinanyl,

30 2,2-dioxido-1,2,3-oxathiazinanyl, 1-oxido-1,2,5-thiadiazolidinyl,

1,1-dioxido-1,2,5-thiadiazolidinyl, 1-oxido-1,2,6-thiadiazinanyl and

1,1-dioxido-1,2,6-thiadiazinanyl; which ring is optionally substituted by 1 or 2 substituents independently selected from halo, nitro, cyano, hydroxy, fluoromethyl, difluoromethyl,

trifluoromethyl, trifluoromethoxy, carboxy, (1-4C)alkyl, (1-4C)alkoxy, (1-4C)alkanoyl, hydroxy(1-4C)alkyl, dihydroxy(2-4C)alkyl, amino(1-4C)alkyl, (1-4C)alkylNH(1-4C)alkyl-, and di[(1-4C)alkyl]N(1-4C)alkyl;
or a pharmaceutically acceptable salt or in-vivo hydrolysable ester thereof.

- 5 In another aspect of the invention is provided a compound of the formula (I) wherein
A is phenylene;
n is 0, 1 or 2;
R⁴ and R⁵ are together $-S-C(R^6)=C(R^7)-$ or $-C(R^7)=C(R^6)-S-$;
R⁶ and R⁷ are independently selected from hydrogen, chloro, bromo and methyl;
10 R¹ is selected from fluoro, chloro, methyl, ethyl, methoxy and $-O-CH_2-O-$;
R² and R³ together with the nitrogen to which they are attached form a ring selected from morpholino, pyrrolyl, piperazinyl, triazolyl, tetrazolyl, imidazolyl, 3-oxazolidinonyl, thiomorpholino, pyrrolinyl, homopiperazinyl, 3,5-dioxapiperidinyl, 3-oxopyrazolin-2-yl, pyrazolyl, pyrazolinyl, 4-oxopyridyl, 2-oxopyrrolidyl, 2-oxoazetidinyl,
15 1-oxidoisothiazolidinyl, 1-oxido-1,2-thiazinanyl, 1,1-dioxidoisothiazolidinyl, 1,1-dioxido-1,2-thiazinanyl, 2-oxopyrrolidinyl, 2-oxopiperidinyl, 2-oxoimidazolidinyl, 2-oxohexahdropyrimidinyl, 2-oxido-1,2,3-oxathiazolidinyl, 2,2-dioxido-1,2,3-oxathiazolidinyl, 2-oxido-1,2,3-oxathiazinanyl, 2,2-dioxido-1,2,3-oxathiazinanyl, 1-oxido-1,2,5-thiadiazolidinyl,
20 1,1-dioxido-1,2,5-thiadiazolidinyl, 1-oxido-1,2,6-thiadiazinanyl and 1,1-dioxido-1,2,6-thiadiazinanyl; which ring is optionally substituted by 1 or 2 substituents independently selected from hydroxy, hydroxy(1-4C)alkyl, amino(1-4C)alkyl, imidazolyl, -(1-4C)alkylS(O)_b(1-4C)alkyl (wherein b is 1 or 2), halo, cyano, fluoromethyl, difluoromethyl, trifluoromethyl, trifluoromethoxy, carboxy, (1-4C)alkyl, (1-4C)alkoxy, and
25 dihydroxy(2-4C)alkyl;
or a pharmaceutically acceptable salt or in-vivo hydrolysable ester thereof.

- In another aspect of the invention is provided a compound of the formula (I) wherein
A is heteroarylene;
n is 0, 1 or 2;
30 R⁴ and R⁵ are together $-S-C(R^6)=C(R^7)-$ or $-C(R^7)=C(R^6)-S-$;
R⁶ and R⁷ are independently selected from hydrogen, chloro, bromo and methyl;
R¹ is selected from fluoro, chloro, methyl, ethyl, methoxy and $-O-CH_2-O-$;
R² and R³ together with the nitrogen to which they are attached form a ring selected from

- morpholino, pyrrolyl, piperazinyl, triazolyl, tetrazolyl, imidazolyl, 3-oxazolidinonyl, thiomorpholino, pyrrolinyl, homopiperazinyl, 3,5-dioxapiperidinyl, 3-oxopyrazolin-2-yl, pyrazolyl, pyrazolinyl, 4-oxopyridyl, 2-oxopyrrolidyl, 2-oxoazetidinyl, 1-oxidoisothiazolidinyl, 1-oxido-1,2-thiazinanyl, 1,1-dioxidoisothiazolidinyl,
- 5 1,1-dioxido-1,2-thiazinanyl, 2-oxopyrrolidinyl, 2-oxopiperidinyl, 2-oxoimidazolidinyl, 2-oxohexahdropyrimidinyl, 2-oxido-1,2,3-oxathiazolidinyl, 2,2-dioxido-1,2,3-oxathiazolidinyl, 2-oxido-1,2,3-oxathiazinanyl, 2,2-dioxido-1,2,3-oxathiazinanyl, 1-oxido-1,2,5-thiadiazolidinyl, 1,1-dioxido-1,2,5-thiadiazolidinyl, 1-oxido-1,2,6-thiadiazinanyl and
- 10 1,1-dioxido-1,2,6-thiadiazinanyl; which ring is optionally substituted by 1 or 2 substituents independently selected from halo, nitro, cyano, hydroxy, fluoromethyl, difluoromethyl, trifluoromethyl, trifluoromethoxy, carboxy, (1-4C)alkyl, (1-4C)alkoxy, (1-4C)alkanoyl, hydroxy(1-4C)alkyl, dihydroxy(2-4C)alkyl, amino(1-4C)alkyl, (1-4C)alkylNH(1-4C)alkyl-, and di[(1-4C)alkyl]N(1-4C)alkyl;
- 15 or a pharmaceutically acceptable salt or in-vivo hydrolysable ester thereof.

In another aspect of the invention is provided a compound of the formula (I) wherein A is heteroarylene;

n is 0, 1 or 2;

R⁴ and R⁵ are together -S-C(R⁶)=C(R⁷)- or -C(R⁷)=C(R⁶)-S-;

- 20 R⁶ and R⁷ are independently selected from hydrogen, chloro, bromo and methyl; R¹ is selected from fluoro, chloro, methyl, ethyl, methoxy and -O-CH₂-O-; R² and R³ together with the nitrogen to which they are attached form a ring selected from morpholino, pyrrolyl, piperazinyl, triazolyl, tetrazolyl, imidazolyl, 3-oxazolidinonyl, thiomorpholino, pyrrolinyl, homopiperazinyl, 3,5-dioxapiperidinyl, 3-oxopyrazolin-2-yl, pyrazolyl, pyrazolinyl, 4-oxopyridyl, 2-oxopyrrolidyl, 2-oxoazetidinyl, 1-oxidoisothiazolidinyl, 1-oxido-1,2-thiazinanyl, 1,1-dioxidoisothiazolidinyl, 1,1-dioxido-1,2-thiazinanyl, 2-oxopyrrolidinyl, 2-oxopiperidinyl, 2-oxoimidazolidinyl, 2-oxohexahdropyrimidinyl, 2-oxido-1,2,3-oxathiazolidinyl, 2,2-dioxido-1,2,3-oxathiazolidinyl, 2-oxido-1,2,3-oxathiazinanyl, 2,2-dioxido-1,2,3-oxathiazinanyl, 1-oxido-1,2,5-thiadiazolidinyl, 1,1-dioxido-1,2,5-thiadiazolidinyl, 1-oxido-1,2,6-thiadiazinanyl and 1,1-dioxido-1,2,6-thiadiazinanyl; which ring is optionally substituted by 1 or 2 substituents independently selected from hydroxy, hydroxy(1-4C)alkyl, amino(1-4C)alkyl, imidazolyl,

-(1-4C)alkylS(O)_b(1-4C)alkyl (wherein b is 1 or 2), halo, cyano, fluoromethyl, difluoromethyl, trifluoromethyl, trifluoromethoxy, carboxy, (1-4C)alkyl, (1-4C)alkoxy, and dihydroxy(2-4C)alkyl;
or a pharmaceutically acceptable salt or in-vivo hydrolysable ester thereof.

- 5 In another aspect of the invention is provided a compound of the formula (I) wherein
A is phenylene;
n is 0, 1 or 2;
R⁴ and R⁵ are together -S-C(R⁶)=C(R⁷)- or -C(R⁷)=C(R⁶)-S-;
R⁶ and R⁷ are independently selected from hydrogen, chloro, bromo and methyl;
10 R¹ is selected from fluoro, chloro, methyl, ethyl, methoxy and -O-CH₂-O-;
R² and R³ together with the nitrogen to which they are attached form a
morpholino, piperazinyl, 3-oxazolidinonyl, thiomorpholino, homopiperazinyl,
3,5-dioxidopiperidinyl, 3-oxopyrazolin-2-yl, 4-oxopyridyl, 2-oxopyrrolidyl, 2-oxoazetidinyl,
1-oxidoisothiazolidinyl, 1-oxido-1,2-thiazinanyl, 1,1-dioxidoisothiazolidinyl,
15 1,1-dioxido-1,2-thiazinanyl, 2-oxopyrrolidinyl, 2-oxopiperidinyl, 2-oxoimidazolidinyl,
2-oxohexahdropyrimidinyl, 2-oxido-1,2,3-oxathiazolidinyl,
2,2-dioxido-1,2,3-oxathiazolidinyl, 2-oxido-1,2,3-oxathiazinanyl,
2,2-dioxido-1,2,3-oxathiazinanyl, 1-oxido-1,2,5-thiadiazolidinyl,
1,1-dioxido-1,2,5-thiadiazolidinyl, 1-oxido-1,2,6-thiadiazinanyl and
20 1,1-dioxido-1,2,6-thiadiazinanyl; which ring is optionally substituted by 1 or 2 substituents
independently selected from halo, cyano, fluoromethyl, difluoromethyl, trifluoromethyl,
trifluoromethoxy, carboxy, (1-4C)alkyl, (1-4C)alkoxy, hydroxy(1-4C)alkyl, and dihydroxy(2-
4C)alkyl;
or a pharmaceutically acceptable salt or in-vivo hydrolysable ester thereof.

- 25 In another aspect of the invention is provided a compound of the formula (I) wherein
A is phenylene;
n is 0, 1 or 2;
R⁴ and R⁵ are together -S-C(R⁶)=C(R⁷)- or -C(R⁷)=C(R⁶)-S-;
R⁶ and R⁷ are independently selected from hydrogen, chloro, bromo and methyl;
30 R¹ is selected from fluoro, chloro, methyl, ethyl, methoxy and -O-CH₂-O-;
R² and R³ together with the nitrogen to which they are attached form a
morpholino, piperazinyl, 3-oxazolidinonyl, thiomorpholino, homopiperazinyl,

- 3,5-dioxidopiperidinyl, 3-oxopyrazolin-2-yl, 4-oxopyridyl, 2-oxopyrrolidyl, 2-oxoazetidinyl,
 1-oxidoisothiazolidinyl, 1-oxido-1,2-thiazinanyl, 1,1-dioxidoisothiazolidinyl,
 1,1-dioxido-1,2-thiazinanyl, 2-oxopyrrolidinyl, 2-oxopiperidinyl, 2-oxoimidazolidinyl,
 2-oxohexahydropyrimidinyl, 2-oxido-1,2,3-oxathiazolidinyl,
 5 2,2-dioxido-1,2,3-oxathiazolidinyl, 2-oxido-1,2,3-oxathiazinanyl,
 2,2-dioxido-1,2,3-oxathiazinanyl, 1-oxido-1,2,5-thiadiazolidinyl,
 1,1-dioxido-1,2,5-thiadiazolidinyl, 1-oxido-1,2,6-thiadiazinanyl and
 1,1-dioxido-1,2,6-thiadiazinanyl; which ring is optionally substituted by 1 or 2 substituents
 independently selected from halo, carboxy, (1-4C)alkyl, (1-4C)alkoxy, hydroxy, amino(1-
 10 4C)alkyl, imidazolyl, -(1-4C)alkylS(O)_b(1-4C)alkyl (wherein b is 1 or 2), hydroxy(1-
 4C)alkyl, and dihydroxy(2-4C)alkyl; or a pharmaceutically acceptable salt or in-vivo
 hydrolysable ester thereof.

In another aspect of the invention is provided a compound of the formula (I) wherein

A is phenylene;

- 15 n is 0, 1 or 2;
 R⁴ and R⁵ are together -S-C(R⁶)=C(R⁷)- or -C(R⁷)=C(R⁶)-S-;
 R⁶ and R⁷ are independently selected from hydrogen, chloro, bromo and methyl;
 R¹ is selected from fluoro, chloro, methyl, ethyl, methoxy and -O-CH₂-O-;
 R² and R³ together with the nitrogen to which they are attached form a
 20 morpholino, piperazinyl, 3-oxazolidinonyl, thiomorpholino, homopiperazinyl,
 3,5-dioxidopiperidinyl, 3-oxopyrazolin-2-yl, 4-oxopyridyl, 2-oxopyrrolidyl, 2-oxoazetidinyl,
 1-oxidoisothiazolidinyl, 1-oxido-1,2-thiazinanyl, 1,1-dioxidoisothiazolidinyl,
 1,1-dioxido-1,2-thiazinanyl, 2-oxopyrrolidinyl, 2-oxopiperidinyl, 2-oxoimidazolidinyl,
 2-oxohexahydropyrimidinyl, 2-oxido-1,2,3-oxathiazolidinyl,
 25 2,2-dioxido-1,2,3-oxathiazolidinyl, 2-oxido-1,2,3-oxathiazinanyl,
 2,2-dioxido-1,2,3-oxathiazinanyl, 1-oxido-1,2,5-thiadiazolidinyl,
 1,1-dioxido-1,2,5-thiadiazolidinyl, 1-oxido-1,2,6-thiadiazinanyl and
 1,1-dioxido-1,2,6-thiadiazinanyl; which ring is optionally substituted by 1 or 2 substituents
 independently selected from halo, carboxy, (1-4C)alkyl, (1-4C)alkoxy, hydroxy(1-4C)alkyl,
 30 and dihydroxy(2-4C)alkyl;
 or a pharmaceutically acceptable salt or in-vivo hydrolysable ester thereof.

In another aspect of the invention is provided a compound of the formula (I) wherein
 A is phenylene;

n is 0, 1 or 2;

R⁴ and R⁵ are together -S-C(R⁶)=C(R⁷)- or -C(R⁷)=C(R⁶)-S-;

R⁶ and R⁷ are independently selected from hydrogen, chloro, bromo and methyl;

R¹ is selected from fluoro, chloro, methyl, ethyl, methoxy and -O-CH₂-O-;

- 5 R² and R³ together with the nitrogen to which they are attached form a morpholino, piperazinyl, 3-oxazolidinonyl, thiomorpholino, homopiperazinyl, 3,5-dioxidopiperidinyl, 3-oxopyrazolin-2-yl, 4-oxopyridyl, 2-oxopyrrolidyl, 2-oxoazetidinyl, 1-oxidoisothiazolidinyl, 1-oxido-1,2-thiazinanyl, 1,1-dioxidoisothiazolidinyl, 1,1-dioxido-1,2-thiazinanyl, 2-oxopyrrolidinyl, 2-oxopiperidinyl, 2-oxoimidazolidinyl,
- 10 2-oxohexahydropyrimidinyl, 2-oxido-1,2,3-oxathiazolidinyl, 2,2-dioxido-1,2,3-oxathiazolidinyl, 2-oxido-1,2,3-oxathiazinanyl, 2,2-dioxido-1,2,3-oxathiazinanyl, 1-oxido-1,2,5-thiadiazolidinyl, 1,1-dioxido-1,2,5-thiadiazolidinyl, 1-oxido-1,2,6-thiadiazinanyl and 1,1-dioxido-1,2,6-thiadiazinanyl; which ring is optionally substituted by 1 or 2 substituents
- 15 independently selected from hydroxy, hydroxy(1-4C)alkyl, amino(1-4C)alkyl, imidazolyl, and -(1-4C)alkylS(O)_b(1-4C)alkyl (wherein b is 1 or 2); or a pharmaceutically acceptable salt or in-vivo hydrolysable ester thereof.

In another aspect of the invention is provided a compound of the formula (I) wherein

A is phenylene;

- 20 n is 0, 1 or 2;
- R⁴ and R⁵ are together -S-C(R⁶)=C(R⁷)- or -C(R⁷)=C(R⁶)-S-;
- R⁶ and R⁷ are independently selected from hydrogen and chloro;
- R¹ is selected from fluoro, chloro, methyl, ethyl, methoxy and -O-CH₂-O-;
- R² and R³ together with the nitrogen to which they are attached form a morpholino, piperazinyl, 3-oxazolidinonyl, thiomorpholino, homopiperazinyl, 3,5-dioxidopiperidinyl, 3-oxopyrazolin-2-yl, 4-oxopyridyl, 2-oxopyrrolidyl, 2-oxoazetidinyl, 1-oxidoisothiazolidinyl, 1-oxido-1,2-thiazinanyl, 1,1-dioxidoisothiazolidinyl, 1,1-dioxido-1,2-thiazinanyl, 2-oxopyrrolidinyl, 2-oxopiperidinyl, 2-oxoimidazolidinyl, 2-oxohexahydropyrimidinyl, 2-oxido-1,2,3-oxathiazolidinyl,
- 25 2,2-dioxido-1,2,3-oxathiazolidinyl, 2-oxido-1,2,3-oxathiazinanyl, 2,2-dioxido-1,2,3-oxathiazinanyl, 1-oxido-1,2,5-thiadiazolidinyl, 1,1-dioxido-1,2,5-thiadiazolidinyl, 1-oxido-1,2,6-thiadiazinanyl and 1,1-dioxido-1,2,6-thiadiazinanyl;
- 30 2,2-dioxido-1,2,3-oxathiazolidinyl, 2-oxido-1,2,3-oxathiazinanyl, 2,2-dioxido-1,2,3-oxathiazinanyl, 1-oxido-1,2,5-thiadiazolidinyl, 1,1-dioxido-1,2,5-thiadiazolidinyl, 1-oxido-1,2,6-thiadiazinanyl and

1,1-dioxido-1,2,6-thiadiazinanyl; which ring is optionally substituted by 1 or 2 substituents independently selected from halo, carboxy, (1-4C)alkyl, (1-4C)alkoxy, hydroxy(1-4C)alkyl, and dihydroxy(2-4C)alkyl;

or a pharmaceutically acceptable salt or in-vivo hydrolysable ester thereof.

5 In another aspect of the invention is provided a compound of the formula (I) wherein A is phenylene;

n is 0, 1 or 2;

R⁴ and R⁵ are together -S-C(R⁶)=C(R⁷)- or -C(R⁷)=C(R⁶)-S-;

R⁶ and R⁷ are independently selected from hydrogen and chloro;

10 R¹ is selected from fluoro, chloro, methyl, ethyl, methoxy and -O-CH₂-O-;
R² and R³ together with the nitrogen to which they are attached form a morpholino, piperazinyl, 3-oxazolidinonyl, thiomorpholino, homopiperazinyl, 3,5-dioxidopiperidinyl, 3-oxopyrazolin-2-yl, 4-oxopyridyl, 2-oxopyrrolidyl, 2-oxoazetidinyl, 1-oxidoisothiazolidinyl, 1-oxido-1,2-thiazinanyl, 1,1-dioxidoisothiazolidinyl,

15 1,1-dioxido-1,2-thiazinanyl, 2-oxopyrrolidinyl, 2-oxopiperidinyl, 2-oxoimidazolidinyl, 2-oxohexahdropyrimidinyl, 2-oxido-1,2,3-oxathiazolidinyl, 2,2-dioxido-1,2,3-oxathiazolidinyl, 2-oxido-1,2,3-oxathiazinanyl, 2,2-dioxido-1,2,3-oxathiazinanyl, 1-oxido-1,2,5-thiadiazolidinyl,

1,1-dioxido-1,2,5-thiadiazolidinyl, 1-oxido-1,2,6-thiadiazinanyl and
20 1,1-dioxido-1,2,6-thiadiazinanyl; which ring is optionally substituted by 1 substituent selected from hydroxy, hydroxy(1-4C)alkyl, amino(1-4C)alkyl, imidazolyl, and -(1-4C)alkylS(O)_b(1-4C)alkyl (wherein b is 1 or 2);
or a pharmaceutically acceptable salt or in-vivo hydrolysable ester thereof.

In another aspect of the invention is provided a compound of the formula (I) wherein

25 A is phenylene;

n is 0;

R⁴ and R⁵ are together -S-C(R⁶)=C(R⁷)- or -C(R⁷)=C(R⁶)-S-;

R⁶ and R⁷ are independently selected from hydrogen and chloro;

30 R² and R³ together with the nitrogen to which they are attached form a morpholino, piperazinyl, 3-oxazolidinonyl, thiomorpholino, homopiperazinyl, 3,5-dioxidopiperidinyl, 3-oxopyrazolin-2-yl, 4-oxopyridyl, 2-oxopyrrolidyl, 2-oxoazetidinyl, 1-oxidoisothiazolidinyl, 1-oxido-1,2-thiazinanyl, 1,1-dioxidoisothiazolidinyl, 1,1-dioxido-1,2-thiazinanyl, 2-oxopyrrolidinyl, 2-oxopiperidinyl, 2-oxoimidazolidinyl,

2-oxohexahydropyrimidinyl, 2-oxido-1,2,3-oxathiazolidinyl,

2,2-dioxido-1,2,3-oxathiazolidinyl, 2-oxido-1,2,3-oxathiazinanyl,

2,2-dioxido-1,2,3-oxathiazinanyl, 1-oxido-1,2,5-thiadiazolidinyl,

1,1-dioxido-1,2,5-thiadiazolidinyl, 1-oxido-1,2,6-thiadiazinanyl and

5 1,1-dioxido-1,2,6-thiadiazinanyl; which ring is optionally substituted by 1 or 2 substituents independently selected from halo, carboxy, (1-4C)alkyl, (1-4C)alkoxy, hydroxy(1-4C)alkyl, and dihydroxy(2-4C)alkyl;

or a pharmaceutically acceptable salt or in-vivo hydrolysable ester thereof.

In another aspect of the invention is provided a compound of the formula (I) wherein

10 A is phenylene;

n is 0;

R⁴ and R⁵ are together -S-C(R⁶)=C(R⁷)- or -C(R⁷)=C(R⁶)-S-;

R⁶ and R⁷ are independently selected from hydrogen and chloro;

R² and R³ together with the nitrogen to which they are attached form a

15 morpholino, piperazinyl, 3-oxazolidinonyl, thiomorpholino, homopiperazinyl,

3,5-dioxidopiperidinyl, 3-oxopyrazolin-2-yl, 4-oxopyridyl, 2-oxopyrrolidyl, 2-oxoazetidinyl,

1-oxidoisothiazolidinyl, 1-oxido-1,2-thiazinanyl, 1,1-dioxidoisothiazolidinyl,

1,1-dioxido-1,2-thiazinanyl, 2-oxopyrrolidinyl, 2-oxopiperidinyl, 2-oxoimidazolidinyl,

2-oxohexahydropyrimidinyl, 2-oxido-1,2,3-oxathiazolidinyl,

20 2,2-dioxido-1,2,3-oxathiazolidinyl, 2-oxido-1,2,3-oxathiazinanyl,

2,2-dioxido-1,2,3-oxathiazinanyl, 1-oxido-1,2,5-thiadiazolidinyl,

1,1-dioxido-1,2,5-thiadiazolidinyl, 1-oxido-1,2,6-thiadiazinanyl and

1,1-dioxido-1,2,6-thiadiazinanyl; which ring is optionally substituted by 1 substituent selected from hydroxy, hydroxy(1-4C)alkyl, amino(1-4C)alkyl, imidazolyl, and -(1-4C)alkylS(O)_b(1-

25 4C)alkyl (wherein b is 1 or 2);

or a pharmaceutically acceptable salt or in-vivo hydrolysable ester thereof.

In another aspect of the invention is provided a compound of the formula (I) wherein

A is phenylene;

n is 0;

30 R⁴ and R⁵ are together -S-C(R⁶)=C(R⁷)- or -C(R⁷)=C(R⁶)-S-;

R⁶ and R⁷ are independently selected from hydrogen and chloro;

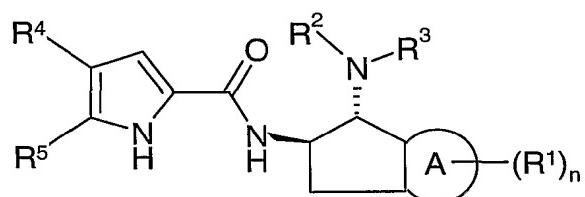
R² and R³ together with the nitrogen to which they are attached form a

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3-oxazolidinonyl or 2-oxopyrrolidinyl ring which ring is optionally substituted by 1 substituent selected from hydroxy, hydroxymethyl, aminomethyl, imidazolyl, methylsulfonylmethyl and methylsulfinylmethyl; or a pharmaceutically acceptable salt or in-vivo hydrolysable ester thereof.

5

Preferred compounds of the invention are of the formula (1A), wherein R¹ to R⁷ and n are as defined in any aspect or embodiment described hereinbefore or hereinafter.



(1A)

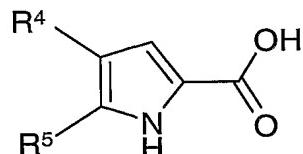
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Particular compounds of the invention are each of the Examples or a pharmaceutically acceptable salt or pro-drug thereof, each of which provides a further independent aspect of the invention. In a further aspect of the invention there is provided any two or more of the Examples or a pharmaceutically acceptable salt or pro-drug thereof.

15

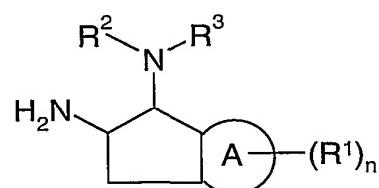
Another aspect of the present invention provides a process for preparing a compound of formula (1) or a pharmaceutically acceptable salt or an in-vivo hydrolysable ester thereof which process (wherein A, R¹ to R⁵ and n are, unless otherwise specified, as defined in formula (1)) comprises of:

20 a) reacting an acid of the formula (2):



(2)

or an activated derivative thereof; with an amine of formula (3):



(3)

25

and thereafter if necessary:

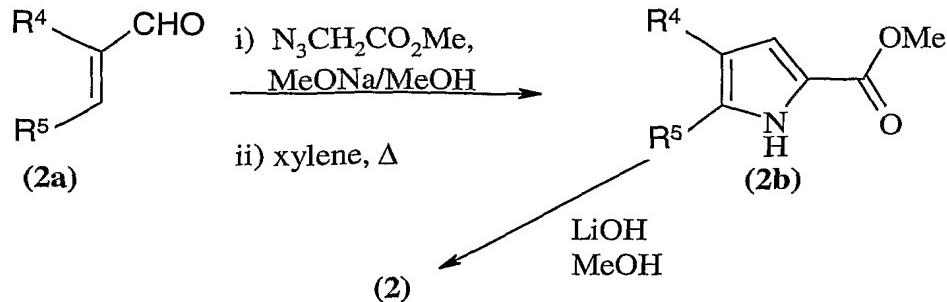
- i) converting a compound of the formula (1) into another compound of the formula (1);
- ii) removing any protecting groups;
- iii) forming a pharmaceutically acceptable salt or in-vivo hydrolysable ester.

5 Specific reaction conditions for the above reaction are as follows.

Process a) Acids of formula (2) and amines of formula (3) may be coupled together in the presence of a suitable coupling reagent. Standard peptide coupling reagents known in the art can be employed as suitable coupling reagents, or for example carbonyldiimidazole, 1-ethyl-3-(3-dimethylaminopropyl)carbodi-imide hydrochloride (EDCI) 10 and dicyclohexyl-carbodiimide (DCCI), optionally in the presence of a catalyst such as 1-hydroxybenzotriazole, dimethylaminopyridine or 4-pyrrolidinopyridine, optionally in the presence of a base for example triethylamine, di-isopropylethylamine, pyridine, or 2,6-di-alkyl-pyridines such as 2,6-lutidine or 2,6-di-*tert*-butylpyridine. Suitable solvents include dimethylacetamide, dichloromethane, benzene, tetrahydrofuran and 15 dimethylformamide. The coupling reaction may conveniently be performed at a temperature in the range of -40 to 40°C.

Suitable activated acid derivatives include acid chlorides, for example acid chlorides, and active esters, for example pentafluorophenyl esters. The reaction of these types of compounds with amines is well known in the art, for example they may be reacted in the 20 presence of a base, such as those described above, and in a suitable solvent, such as those described above. The reaction may conveniently be performed at a temperature in the range of -40 to 40°C.

A compounds of formula (2) may be prepared according to Scheme 1:



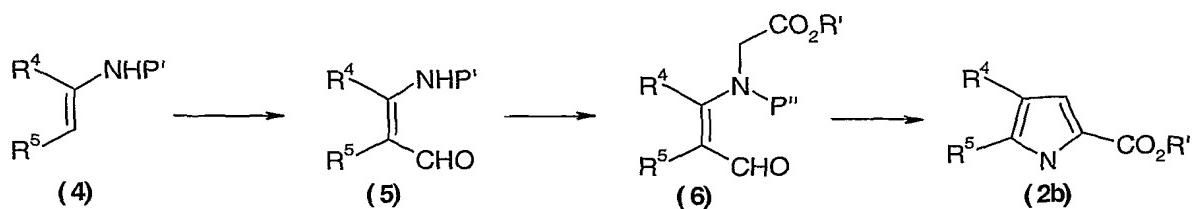
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Scheme 1

Compounds of formula (2a) are commercially available or they are known compounds or they are prepared by processes known in the art.

Compounds of formula (2b) may also be prepared as illustrated in Scheme 2:

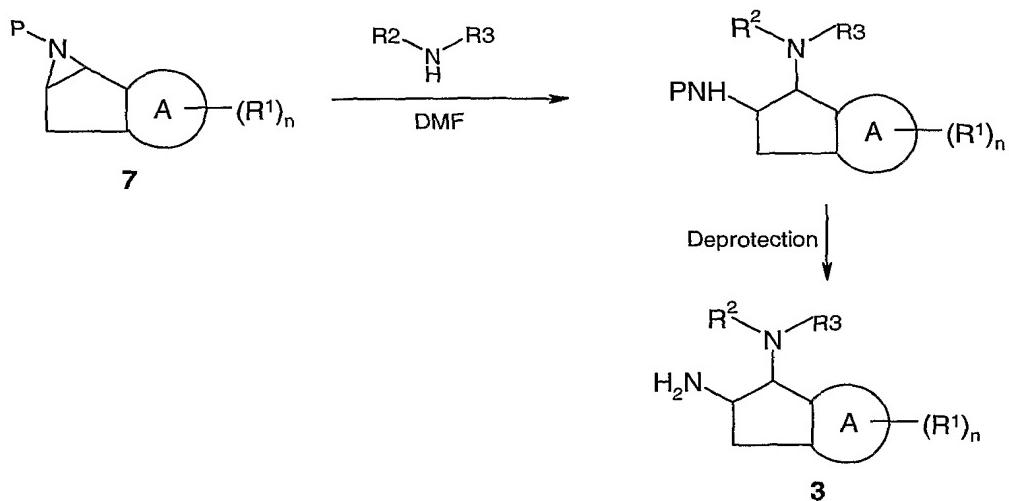
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Scheme 2

The conversion of compounds of formula (4) into compounds of formula (5) may be carried out by directed ortho lithiation reactions (J. Org. Chem., 2001, volume 66, 3662-3670),
 5 for example with n-butyl lithium and $(\text{CHO})\text{N}(\text{alkyl})_2$. The protecting group P' in compounds of formula (4) must be suitable directing group for this reaction and may be for example $-\text{CO}_2\text{tBu}$. Reaction of compounds of formula (5) with $\text{LCH}_2\text{CO}_2\text{R}$ where L is a leaving group, and replacement of the protecting group P' with an alternative P'' (for example $-\text{COalkyl}$) according to standard processes, gives a compound of formula (6). This may be
 10 cyclised using a base, for example potassium carbonate or sodium methoxide.

Compounds of formula (3) may be prepared according to Scheme 3: (wherein P is a protecting group such as tert-butyloxycarbonyl (Boc), p-toluenesulfonate (tosylate) or methanesulfonate (mesylate) group).

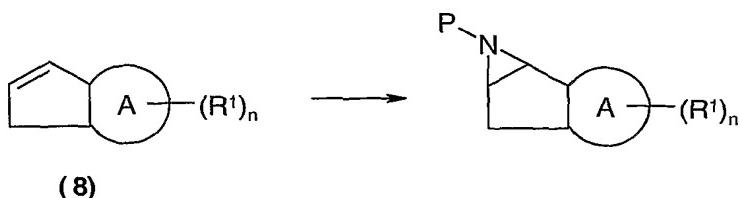


15

Compounds of formula R²-NH-R³ are commercially available or they are known compounds or they are prepared by processes known in the art.

Compounds of the formula (7) may be made, for example, starting from olefins of formula (8), subjection of the olefin to aziridination would result in the suitably protected aziridine (7) in which P is H or a suitable protecting group.

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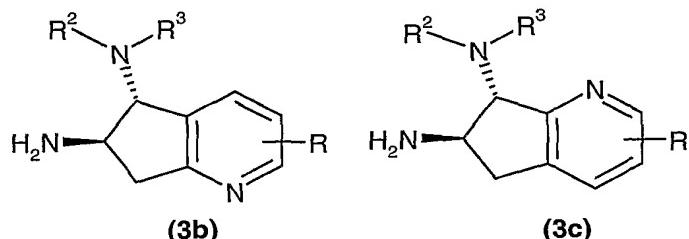


Alternatively, compound of formula (3) may be prepared by the cyclisation of a group R^{2a}-Y, (wherein Y is a nucleophile such as OH, NH₂ or SH, and R^{2a} is a group such as (1-3C)alkylsulfonyl, (1-3C)alkylcarbonyl or (1-3C)alkyl, optionally substituted by any of the optional substituents for the ring defined by R²-N-R³ or by a carbonyl or sulfonyl group) with a group R^{3a}-X (wherein X is a leaving group such as F, Cl, Br, mesylate or tosylate, and R^{3a} is a group such as (1-3C)alkylsulfonyl, (1-3C)alkylcarbonyl or (1-3C)alkyl, optionally substituted by any of the optional substituents for the ring defined by R²-N-R³ or by a carbonyl or sulfonyl group), as shown in Scheme 4.



Scheme 4

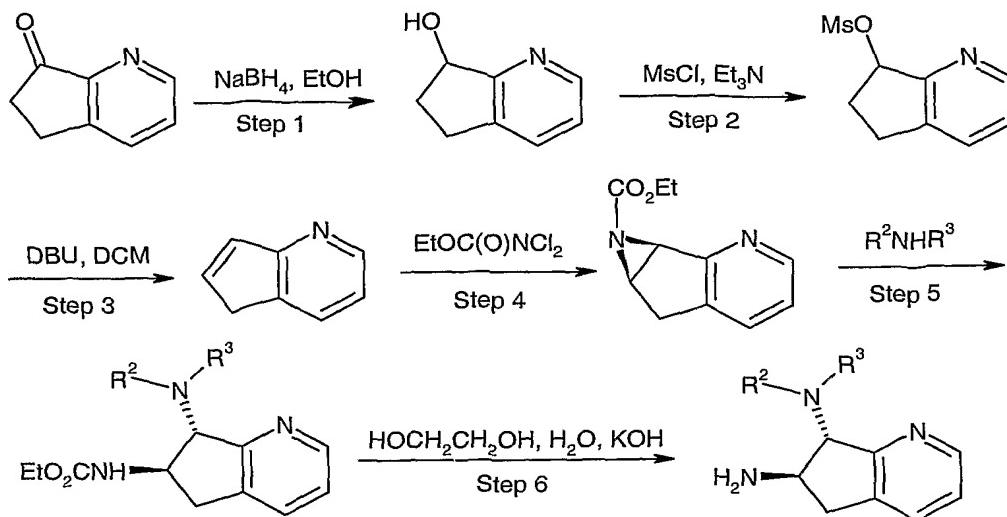
Compounds of the formula (3) where $r = 1$ and wherein A is heteroarylene can be prepared from suitably functionalised cycloalkyl fused heterocycles. For example, when A is pyridine,



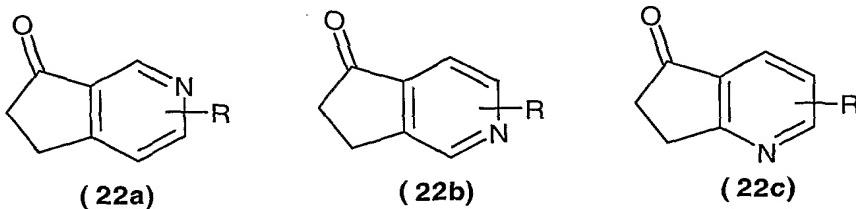
15

compounds of formula (3b) and (3c) may be prepared from the corresponding azaindaneone regioisomer according to Scheme 5 :-

-30-

**Scheme 5**

Steps 1, 2, 3, 4, 5 and 6 are known in the literature or they are standard transformation known in the art. The regiosomeric azaindanones (22a, 22b, 22c) are known in the literature or they are prepared by processes known in the art. It will be appreciated that starting from these alternative azaindanones will give rise to the regiosomeric pyridyl products.



The process described above and shown in Scheme 4 may also be applied to other six membered heterocycles containing more than one nitrogen.

It will be appreciated that, in a similar manner, compounds of the formula (3) wherein A is heteroarylene containing a bridgehead nitrogen can be prepared from the appropriate suitably functionalised cycloalkyl fused heterocycles.

It will be appreciated that certain of the various ring substituents in the compounds of the present invention, for example R¹ may be introduced by standard aromatic substitution reactions or generated by conventional functional group modifications either prior to or immediately following the processes mentioned above, and as such are included in the process aspect of the invention. Such reactions may convert one compound of the formula (1) into another compound of the formula (1). Such reactions and modifications include, for example, introduction of a substituent by means of an aromatic substitution reaction,

reduction of substituents, alkylation of substituents and oxidation of substituents. The reagents and reaction conditions for such procedures are well known in the chemical art. Particular examples of aromatic substitution reactions include the introduction of a nitro group using concentrated nitric acid, the introduction of an acyl group using, for example, an acyl halide and Lewis acid (such as aluminium trichloride) under Friedel Crafts conditions; the introduction of an alkyl group using an alkyl halide and Lewis acid (such as aluminium trichloride) under Friedel Crafts conditions; and the introduction of a halogen group. Particular examples of modifications include the reduction of a nitro group to an amino group by for example, catalytic hydrogenation with a nickel catalyst or treatment with iron in the presence of hydrochloric acid with heating; oxidation of alkylthio to alkylsulphinyl or alkylsulphonyl.

It will also be appreciated that in some of the reactions mentioned herein it may be necessary/desirable to protect any sensitive groups in the compounds. The instances where protection is necessary or desirable and suitable methods for protection are known to those skilled in the art. Conventional protecting groups may be used in accordance with standard practice (for illustration see T.W. Green, Protective Groups in Organic Synthesis, John Wiley and Sons, 1991). Thus, if reactants include groups such as amino, carboxy or hydroxy it may be desirable to protect the group in some of the reactions mentioned herein.

A suitable protecting group for an amino or alkylamino group is, for example, an acyl group, for example an alkanoyl group such as acetyl, an alkoxy carbonyl group, for example a methoxycarbonyl, ethoxycarbonyl or *t*-butoxycarbonyl group, an arylmethoxycarbonyl group, for example benzyloxycarbonyl, or an aroyl group, for example benzoyl. The deprotection conditions for the above protecting groups necessarily vary with the choice of protecting group. Thus, for example, an acyl group such as an alkanoyl or alkoxy carbonyl group or an aroyl group may be removed for example, by hydrolysis with a suitable base such as an alkali metal hydroxide, for example lithium or sodium hydroxide. Alternatively an acyl group such as a *t*-butoxycarbonyl group may be removed, for example, by treatment with a suitable acid as hydrochloric, sulphuric or phosphoric acid or trifluoroacetic acid and an arylmethoxycarbonyl group such as a benzyloxycarbonyl group may be removed, for example, by hydrogenation over a catalyst such as palladium-on-carbon, or by treatment with a Lewis acid for example boron tris(trifluoroacetate). A suitable alternative protecting group for a primary amino group is, for example, a phthaloyl group which may be removed by treatment with an alkylamine, for example dimethylaminopropylamine, or with hydrazine.

A suitable protecting group for a hydroxy group is, for example, an acyl group, for example an alkanoyl group such as acetyl, an aroyl group, for example benzoyl, or an arylmethyl group, for example benzyl. The deprotection conditions for the above protecting groups will necessarily vary with the choice of protecting group. Thus, for example, an acyl
5 group such as an alkanoyl or an aroyl group may be removed, for example, by hydrolysis with a suitable base such as an alkali metal hydroxide, for example lithium or sodium hydroxide. Alternatively an arylmethyl group such as a benzyl group may be removed, for example, by hydrogenation over a catalyst such as palladium-on-carbon.

A suitable protecting group for a carboxy group is, for example, an esterifying group,
10 for example a methyl or an ethyl group which may be removed, for example, by hydrolysis with a base such as sodium hydroxide, or for example a *t*-butyl group which may be removed, for example, by treatment with an acid, for example an organic acid such as trifluoroacetic acid, or for example a benzyl group which may be removed, for example, by hydrogenation over a catalyst such as palladium-on-carbon.

15 The protecting groups may be removed at any convenient stage in the synthesis using conventional techniques well known in the chemical art.

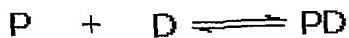
Certain intermediates in the preparation of a compound of the formula (1) are novel and form another aspect of the invention.

The thermodynamic solubility data for the compounds of the invention as given above
20 may be measured by agitating the compound in 0.1 M phosphate at pH7.4 for 24hours, then analysis of the supernatant (for example by LCUV/MS) using a solution (for example in DMSO) of known concentration as the calibrant.

Plasma Protein binding may be measured using an equilibrium dialysis technique,
whereby compound is added to 10% plasma giving a concentration of 20 μ M and dialysed
25 with isotonic buffer for 18 hours at 37°C. The plasma and buffer solutions are analysed using LCUVMS and the first apparent binding constant for the compound derived. The binding constant is then used to determine the % free in 100% plasma.

The binding constant derived from the dialysis experiment is based upon a model of 1:1 binding between compound and albumin.

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$$K_1 = \frac{[PD]}{[P] \times [D]}$$

where P = free protein, D = free drug, PD = drug protein complex, K1 = first apparent binding constant.

5 As stated hereinbefore the compounds defined in the present invention possesses glycogen phosphorylase inhibitory activity. This property may be assessed, for example, using the procedure set out below.

Assay

The activity of the compounds is determined by measuring the inhibitory effect of the 10 compounds on glycogen degradation, the production of glucose-1-phosphate from glycogen is monitored by the multienzyme coupled assay, as described in EP 0 846 464 A2, general method of Pesce et al (Pesce, M A, Bodourian, S H, Harris, R C, and Nicholson, J F (1977) Clinical Chemistry 23, 1171 - 1717). The reactions were in 384well microplate format in a volume of 50µl. The change in fluorescence due to the conversion of the co-factor NAD to 15 NADH is measured at 340nM excitation, 465nm emission in a Tecan Ultra Multifunctional Microplate Reader. The reaction is in 50mM HEPES, 3.5mM KH₂PO₄, 2.5mM MgCl₂, 2.5mM ethylene glycol-bis(b-aminoethyl ether) N,N,N',N'-tetraacetic acid, 100mM KCl, 8mM D-(+)-glucose pH7.2, containing 0.5mM dithiothreitol, the assay buffer solution. Human recombinant liver glycogen phosphorylase *a* (hrl GP*a*) 20nM is pre-incubated in assay buffer 20 solution with 6.25mM NAD, 1.25mg type III glycogen at 1.25 mg ml⁻¹ the reagent buffer, for 30 minutes. The coupling enzymes, phosphoglucomutase and glucose-6-phosphate dehydrogenase (Sigma) are prepared in reagent buffer, final concentration 0.25Units per well. 20µl of the hrl GP*a* solution is added to 10µl compound solution and the reaction started with the addition of 20ul coupling enzyme solution. Compounds to be tested are prepared in 25 10µl 5% DMSO in assay buffer solution, with final concentration of 1% DMSO in the assay. The non-inhibited activity of GP*a* is measured in the presence of 10µl 5% DMSO in assay buffer solution and maximum inhibition measured in the presence of 5mgs ml⁻¹ N-ethylmaleimide. After 6 hours at 30°C Relative Fluorescence Units (RFUs) are measured at 340nM excitation, 465nm emission .

The assay is performed at a test concentration of inhibitor of 10 μ M or 100 μ M. Compounds demonstrating significant inhibition at one or both of these concentrations may be further evaluated using a range of test concentrations of inhibitor to determine an IC₅₀, a concentration predicted to inhibit the enzyme reaction by 50%.

5 Activity is calculated as follows:-

% inhibition = (1 - (compound RFUs - fully inhibited RFUs)/ (non-inhibited rate RFUs - fully inhibited RFUs)) * 100.

Typical IC₅₀ values for compounds of the invention when tested in the above assay are in the range 100 μ M to 1nM. Compounds of the Examples typically have IC₅₀ values of less 10 than 10 μ M. For example, Example 6 gave an value of 0.04 μ M.

The inhibitory activity of compounds was further tested in rat primary hepatocytes.

Rat hepatocytes were isolated by the collagenase perfusion technique, general method of Seglen (P.O. Seglen, Methods Cell Biology (1976) 13 29-83). Cells were cultured on Nunclon six well culture plates in DMEM (Dulbecco's Modified Eagle's Medium) with high level of 15 glucose containing 10% foetal calf serum, NEAA (non essential amino acids), Glutamine, penicillin /streptomycin ((100units/100ug)/ml) for 4 to 6 hours. The hepatocytes were then cultured in the DMEM solution without foetal calf serum and with 10nM insulin and 10nM dexamethasone. Experiments were initiated after 18-20 hours culture by washing the cells and adding Krebs-Henseleit bicarbonate buffer containing 2.5mM CaCl₂ and 1% gelatin. The test 20 compound was added and 5 minutes later the cells were challenged with 25nM glucagon. The Krebs-Henseleit solution was removed after 60 min incubation at 37°C , 95%O₂/5%CO₂ and the glucose concentration of the Krebs-Henseleit solution measured.

According to a further aspect of the invention there is provided a pharmaceutical composition which comprises a compound of the formula (1), or a pharmaceutically acceptable salt or *in vivo* hydrolysable ester thereof, as defined hereinbefore in association 25 with a pharmaceutically-acceptable diluent or carrier.

The compositions of the invention may be in a form suitable for oral use (for example as tablets, lozenges, hard or soft capsules, aqueous or oily suspensions, emulsions, dispersible powders or granules, syrups or elixirs), for topical use (for example as creams, ointments, 30 gels, or aqueous or oily solutions or suspensions), for administration by inhalation (for example as a finely divided powder or a liquid aerosol), for administration by insufflation (for example as a finely divided powder) or for parenteral administration (for example as a sterile

aqueous or oily solution for intravenous, subcutaneous, intramuscular or intramuscular dosing or as a suppository for rectal dosing).

The compositions of the invention may be obtained by conventional procedures using conventional pharmaceutical excipients, well known in the art. Thus, compositions intended 5 for oral use may contain, for example, one or more colouring, sweetening, flavouring and/or preservative agents. In one aspect, the compositions of the invention are in a form suitable for oral dosage.

Suitable pharmaceutically acceptable excipients for a tablet formulation include, for example, inert diluents such as lactose, sodium carbonate, calcium phosphate or calcium 10 carbonate, granulating and disintegrating agents such as corn starch or algenic acid; binding agents such as starch; lubricating agents such as magnesium stearate, stearic acid or talc; preservative agents such as ethyl or propyl p-hydroxybenzoate, and anti-oxidants, such as ascorbic acid. Tablet formulations may be uncoated or coated either to modify their disintegration and the subsequent absorption of the active ingredient within the 15 gastrointestinal tract, or to improve their stability and/or appearance, in either case, using conventional coating agents and procedures well known in the art.

Compositions for oral use may be in the form of hard gelatin capsules in which the active ingredient is mixed with an inert solid diluent, for example, calcium carbonate, calcium phosphate or kaolin, or as soft gelatin capsules in which the active ingredient is mixed with 20 water or an oil such as peanut oil, liquid paraffin, or olive oil.

Aqueous suspensions generally contain the active ingredient in finely powdered form together with one or more suspending agents, such as sodium carboxymethylcellulose, methylcellulose, hydroxypropylmethylcellulose, sodium alginate, polyvinyl-pyrrolidone, gum tragacanth and gum acacia; dispersing or wetting agents such as lecithin or condensation 25 products of an alkylene oxide with fatty acids (for example polyoxethylene stearate), or condensation products of ethylene oxide with long chain aliphatic alcohols, for example heptadecaethyleneoxycetanol, or condensation products of ethylene oxide with partial esters derived from fatty acids and a hexitol such as polyoxyethylene sorbitol monooleate, or condensation products of ethylene oxide with long chain aliphatic alcohols, for example 30 heptadecaethyleneoxycetanol, or condensation products of ethylene oxide with partial esters derived from fatty acids and a hexitol such as polyoxyethylene sorbitol monooleate, or condensation products of ethylene oxide with partial esters derived from fatty acids and hexitol anhydrides, for example polyethylene sorbitan monooleate. The aqueous suspensions

may also contain one or more preservatives (such as ethyl or propyl p-hydroxybenzoate, anti-oxidants (such as ascorbic acid), colouring agents, flavouring agents, and/or sweetening agents (such as sucrose, saccharine or aspartame).

Oily suspensions may be formulated by suspending the active ingredient in a

5 vegetable oil (such as arachis oil, olive oil, sesame oil or coconut oil) or in a mineral oil (such as liquid paraffin). The oily suspensions may also contain a thickening agent such as beeswax, hard paraffin or cetyl alcohol. Sweetening agents such as those set out above, and flavouring agents may be added to provide a palatable oral preparation. These compositions may be preserved by the addition of an anti-oxidant such as ascorbic acid.

10 Dispersible powders and granules suitable for preparation of an aqueous suspension by the addition of water generally contain the active ingredient together with a dispersing or wetting agent, suspending agent and one or more preservatives. Suitable dispersing or wetting agents and suspending agents are exemplified by those already mentioned above. Additional excipients such as sweetening, flavouring and colouring agents, may also be
15 present.

The pharmaceutical compositions of the invention may also be in the form of oil-in-water emulsions. The oily phase may be a vegetable oil, such as olive oil or arachis oil, or a mineral oil, such as for example liquid paraffin or a mixture of any of these. Suitable emulsifying agents may be, for example, naturally-occurring gums such as gum acacia or gum
20 tragacanth, naturally-occurring phosphatides such as soya bean, lecithin, an esters or partial esters derived from fatty acids and hexitol anhydrides (for example sorbitan monooleate) and condensation products of the said partial esters with ethylene oxide such as polyoxyethylene sorbitan monooleate. The emulsions may also contain sweetening, flavouring and preservative agents.

25 Syrups and elixirs may be formulated with sweetening agents such as glycerol, propylene glycol, sorbitol, aspartame or sucrose, and may also contain a demulcent, preservative, flavouring and/or colouring agent.

The pharmaceutical compositions may also be in the form of a sterile injectable aqueous or oily suspension, which may be formulated according to known procedures using
30 one or more of the appropriate dispersing or wetting agents and suspending agents, which have been mentioned above. A sterile injectable preparation may also be a sterile injectable solution or suspension in a non-toxic parenterally-acceptable diluent or solvent, for example a solution in 1,3-butanediol.

Compositions for administration by inhalation may be in the form of a conventional pressurised aerosol arranged to dispense the active ingredient either as an aerosol containing finely divided solid or liquid droplets. Conventional aerosol propellants such as volatile fluorinated hydrocarbons or hydrocarbons may be used and the aerosol device is conveniently 5 arranged to dispense a metered quantity of active ingredient.

For further information on formulation the reader is referred to Chapter 25.2 in Volume 5 of Comprehensive Medicinal Chemistry (Corwin Hansch; Chairman of Editorial Board), Pergamon Press 1990.

The amount of active ingredient that is combined with one or more excipients to 10 produce a single dosage form will necessarily vary depending upon the host treated and the particular route of administration. For example, a formulation intended for oral administration to humans will generally contain, for example, from 0.5 mg to 2 g of active agent compounded with an appropriate and convenient amount of excipients which may vary from about 5 to about 98 percent by weight of the total composition. Dosage unit forms will 15 generally contain about 1 mg to about 500 mg of an active ingredient. For further information on Routes of Administration and Dosage Regimes the reader is referred to Chapter 25.3 in Volume 5 of Comprehensive Medicinal Chemistry (Corwin Hansch; Chairman of Editorial Board), Pergamon Press 1990.

The compound of formula (1) will normally be administered to a warm-blooded 20 animal at a unit dose within the range 5-5000 mg per square meter body area of the animal, i.e. approximately 0.1-100 mg/kg, and this normally provides a therapeutically-effective dose. A unit dose form such as a tablet or capsule will usually contain, for example 1-250 mg of 25 active ingredient. Preferably a daily dose in the range of 1-50 mg/kg is employed. However the daily dose will necessarily be varied depending upon the host treated, the particular route of administration, and the severity of the illness being treated. Accordingly the optimum dosage may be determined by the practitioner who is treating any particular patient.

The inhibition of glycogen phosphorylase activity described herein may be applied as a sole therapy or may involve, in addition to the subject of the present invention, one or more other substances and/or treatments. Such conjoint treatment may be achieved by way of the 30 simultaneous, sequential or separate administration of the individual components of the treatment. Simultaneous treatment may be in a single tablet or in separate tablets. For example, in order to prevent, delay or treat type 2 diabetes mellitus, the compounds of the

present invention or their pharmaceutically acceptable salts may be administered in combination with one or more of the following agent(s):

- 1) Insulin and insulin analogues;
- 2) Insulin secretagogues including sulphonylureas (for example glibenclamide, glipizide), prandial glucose regulators (for example repaglinide, nateglinide) and glucokinase activators
- 5 3) Agents that improve incretin action (for example dipeptidyl peptidase IV inhibitors, GLP-1 agonists)
- 4) Insulin sensitising agents including PPARgamma agonists (for example pioglitazone and rosiglitazone); and agents with combined PPARalpha and gamma activity
- 10 5) Agents that modulate hepatic glucose balance (for example metformin, fructose 1, 6 bisphosphatase inhibitors, glycogen synthase inhibitors, glucokinase activators)
- 6) Agents designed to reduce the absorption of glucose from the intestine (for example acarbose);
- 15 7) Agents that prevent the reabsorption of glucose by the kidney (SGLT inhibitors)
- 8) Agents designed to treat the complications of prolonged hyperglycaemia (for example aldose reductase inhibitors)
- 9) Anti-obesity agents (for example sibutramine and orlistat);
- 10) Anti- dyslipidaemia agents such as, HMG-CoA reductase inhibitors (statins, eg 20 pravastatin); PPAR α agonists (fibrates, eg gemfibrozil); bile acid sequestrants (cholestyramine); cholesterol absorption inhibitors (plant stanols, synthetic inhibitors); bile acid absorption inhibitors (IBATi) and nicotinic acid and analogues (niacin and slow release formulations);
- 11) Antihypertensive agents such as, β blockers (eg atenolol, inderal); ACE inhibitors (eg 25 lisinopril); Calcium antagonists (eg. nifedipine); Angiotensin receptor antagonists (eg candesartan), α antagonists and diuretic agents (eg. furosemide, benzthiazide);
- 12) Haemostasis modulators such as, antithrombotics, activators of fibrinolysis and antiplatelet agents; thrombin antagonists; factor Xa inhibitors; factor VIIa inhibitors); antiplatelet agents (eg. aspirin, clopidogrel); anticoagulants (heparin and Low 30 molecular weight analogues, hirudin) and warfarin;
- 13) Agents which antagonise the actions of glucagon; and
- 14) Anti-inflammatory agents, such as non-steroidal anti-inflammatory drugs (eg. aspirin) and steroid anti-inflammatory agents (eg. cortisone).

According to a further aspect of the present invention there is provided a compound of the formula (1), or a pharmaceutically acceptable salt or *in vivo* hydrolysable ester thereof, as defined hereinbefore, for use in a method of treatment of a warm-blooded animal such as man by therapy.

5 According to an additional aspect of the invention there is provided a compound of the formula (1), or a pharmaceutically acceptable salt or *in vivo* hydrolysable ester thereof, as defined hereinbefore, for use as a medicament.

According to an additional aspect of the invention there is provided a compound of the formula (1), or a pharmaceutically acceptable salt or *in vivo* hydrolysable ester thereof, as 10 defined hereinbefore, for use as a medicament in the treatment of type 2 diabetes, insulin resistance, syndrome X, hyperinsulinaemia, hyperglucagonaemia, cardiac ischaemia or obesity in a warm-blooded animal such as man.

According to this another aspect of the invention there is provided the use of a compound of the formula (1), or a pharmaceutically acceptable salt or *in-vivo* hydrolysable ester thereof, as defined hereinbefore in the manufacture of a medicament for use in the 15 treatment of type 2 diabetes, insulin resistance, syndrome X, hyperinsulinaemia, hyperglucagonaemia, cardiac ischaemia or obesity in a warm-blooded animal such as man.

According to this another aspect of the invention there is provided the use of a compound of the formula (1), or a pharmaceutically acceptable salt or *in-vivo* hydrolysable ester thereof, as defined hereinbefore in the manufacture of a medicament for use in the 20 treatment of type 2 diabetes in a warm-blooded animal such as man.

According to a further feature of this aspect of the invention there is provided a method of producing a glycogen phosphorylase inhibitory effect in a warm-blooded animal, such as man, in need of such treatment which comprises administering to said animal an 25 effective amount of a compound of formula (1).

According to this further feature of this aspect of the invention there is provided a method of treating type 2 diabetes, insulin resistance, syndrome X, hyperinsulinaemia, hyperglucagonaemia, cardiac ischaemia or obesity in a warm-blooded animal, such as man, in need of such treatment which comprises administering to said animal an effective amount of a 30 compound of formula (1).

According to this further feature of this aspect of the invention there is provided a method of treating type 2 diabetes in a warm-blooded animal, such as man, in need of such

treatment which comprises administering to said animal an effective amount of a compound of formula (1).

As stated above the size of the dose required for the therapeutic or prophylactic treatment of a particular cell-proliferation disease will necessarily be varied depending on the 5 host treated, the route of administration and the severity of the illness being treated. A unit dose in the range, for example, 1-100 mg/kg, preferably 1-50 mg/kg is envisaged.

In addition to their use in therapeutic medicine, the compounds of formula (1) and their pharmaceutically acceptable salts are also useful as pharmacological tools in the development and standardisation of *in vitro* and *in vivo* test systems for the evaluation of the 10 effects of inhibitors of cell cycle activity in laboratory animals such as cats, dogs, rabbits, monkeys, rats and mice, as part of the search for new therapeutic agents.

In the above other pharmaceutical composition, process, method, use and medicament manufacture features, the alternative and preferred embodiments of the compounds of the invention described herein also apply.

15

Examples

The invention will now be illustrated by the following examples in which, unless stated otherwise:

- 20 (i) temperatures are given in degrees Celsius (°C); operations were carried out at room or ambient temperature, that is, at a temperature in the range of 18-25°C and under an atmosphere of an inert gas such as argon;
- (ii) organic solutions were dried over anhydrous magnesium sulphate; evaporation of solvent was carried out using a rotary evaporator under reduced pressure (600-4000 Pascals; 4.5-30 mmHg) with a bath temperature of up to 60°C;
- 25 (iii) chromatography means flash chromatography on silica gel; thin layer chromatography (TLC) was carried out on silica gel plates;
- (iv) in general, the course of reactions was followed by TLC and reaction times are given for illustration only;
- 30 (v) yields are given for illustration only and are not necessarily those which can be obtained by diligent process development; preparations were repeated if more material was required;
- (vi) where given, NMR data is in the form of delta values for major diagnostic protons, given in parts per million (ppm) relative to tetramethylsilane (TMS) as an internal standard,

determined at 300 MHz using perdeuterio dimethyl sulphoxide ($\text{DMSO}-\delta_6$) as solvent unless otherwise indicated, other solvents (where indicated in the text) include deuterated chloroform CDCl_3 ;

(vii) chemical symbols have their usual meanings; SI units and symbols are used;

5 (viii) reduced pressures are given as absolute pressures in Pascals (Pa); elevated pressures are given as gauge pressures in bars;

(ix) solvent ratios are given in volume : volume (v/v) terms;

(x) mass spectra (MS) were run with an electron energy of 70 electron volts in the chemical ionisation (CI) mode using a direct exposure probe; where indicated ionisation was effected

10 by electron impact (EI), fast atom bombardment (FAB) or electrospray (ESP); values for m/z are given; generally, only ions which indicate the parent mass are reported and unless otherwise stated the value quoted is $(\text{M}-\text{H})^-$;

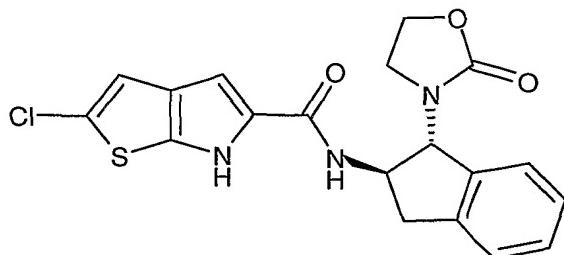
(xi) The following abbreviations may be used:

	SM	starting material;
15	EtOAc	ethyl acetate;
	MeOH	methanol;
	EtOH	ethanol;
	DCM	dichloromethane;
	HOBr	1-hydroxybenzotriazole;
20	DIPEA	di-isopropylethylamine;
	EDCI	1-ethyl-3-(3-dimethylaminopropyl)carbodiimide hydrochloride;
	Et ₂ O	diethyl ether;
	THF	tetrahydrofuran;
25	DMF	<i>N,N</i> -dimethylformamide;
	HATU	<i>O</i> -(7-Azabenzotriazol-1-yl)- <i>N,N,N',N'</i> -tetramethyluroniumhexafluorophosphate
	EDAC	1-(3-dimethylaminopropyl)-3-ethyl-carbodiimide hydrochloride
30	TFA	Trifluoroacetic acid
	DMTMM	4-(4,6-Dimethoxy-1,3,5-triazin-2-yl)-4-methylmorpholinium chloride
	DMA	<i>N,N</i> -dimethylacetamide

NaHMDS	Sodium hexamethyldisilazide
MeCN	acetonitrile
m-CPBA	meta-chloroperbenzoic acid

The Examples and Intermediates were named using the "Name" module in the ACD 5.0
5 program suite [Advanced Chemistry Development (Toronto, Canada)]

Example 1: 2-Chloro-N-[(1*R*,2*R*)-1-(2-oxo-1,3-oxazolidin-3-yl)-2,3-dihydro-1*H*-inden-2-yl]-6*H*-thieno[2,3-*b*]pyrrole-5-carboxamide

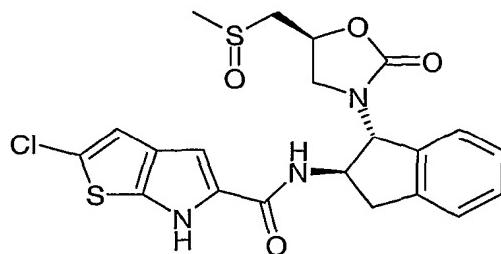


10 4-Nitrobenzyl ((1*R*,2*R*)-2-{[(2-chloro-6*H*-thieno[2,3-*b*]pyrrol-5-yl)carbonyl]amino}-2,3-dihydro-1*H*-inden-1-yl)(2-hydroxyethyl)carbamate (**Intermediate 1**; 222 mg, 0.4 mmol) was dissolved in anhydrous DMA (3 mL), sodium hydride (48 mg, 60% dispersion in mineral oil, 1.2 mmol) added and the reaction stirred at ambient temperature for 3 h. Water (25 mL) was added and the aqueous phase extracted with ethyl acetate (2 x 20 mL). The organic extracts 15 were washed with water (6 x 20 mL) then brine (20 mL) and dried (MgSO_4). The volatiles were removed under reduced pressure and the residue purified by silica gel chromatography (EtOAc:iso-hexane, 1:1) to give the title compound (110 mg, 68%) as a foam.

^1H NMR δ : 3.03 (m, 1H), 3.18 (m, 1H), 3.68 (m, 1H), 4.3 (m, 2H), 4.78 (m, 1H), 5.3 (d, 1H), 6.98 (d, 1H), 7.15 (m, 2H), 7.26 (m, 3H), 8.6 (d, 1H), 11.89 (s, 1H); MS m/z 400, 402 (M-H).

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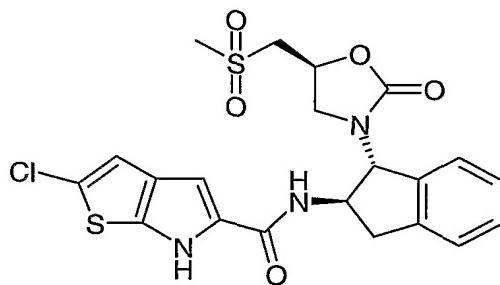
Example 2: 2-Chloro-N-((1*R*,2*R*)-1-{(5*S*)-5-[(methylsulfinyl)methyl]-2-oxo-1,3-oxazolidin-3-yl}-2,3-dihydro-1*H*-inden-2-yl)-6*H*-thieno[2,3-*b*]pyrrole-5-carboxamide



2-Chloro-N-((1*R*,2*R*)-1-{(5*S*)-5-[(methylthio)methyl]-2-oxo-1,3-oxazolidin-3-yl}-2,3-dihydro-1*H*-inden-2-yl)-6*H*-thieno[2,3-*b*]pyrrole-5-carboxamide (**Intermediate 11**; 125 mg, 0.27 mmol) and *m*-CPBA (69 mg, ~70% purity, ~0.28 mmol) were dissolved in THF (2.5 mL) and the reaction stirred at ambient temperature for 2 h. The volatiles were removed under reduced pressure and the crude dissolved in EtOAc (20 mL). The organic phase was washed with saturated aqueous sodium bicarbonate solution (20 mL), water (20 mL) and brine (20 mL). The organic phase was dried (MgSO_4) and the volatiles removed under reduced pressure. Purification by flash column chromatography (SiO_2 , EtOAc to 9:1 EtOAc:MeOH) afforded the title compound (70 mg, 56%) as a solid.

¹⁰ ^1H NMR δ : 2.62 (s, 1.5H), 2.65 (s, 1.5H), 3.20 (m, 4H), 3.50 (m, 2H), 4.78 (m, 1H), 5.00 (m, 1H), 5.28 (d, 1H), 7.00 (s, 1H), 7.25 (m, 5H), 8.60 (d, 1H), 11.82 (s, 1H); MS m/z 478.

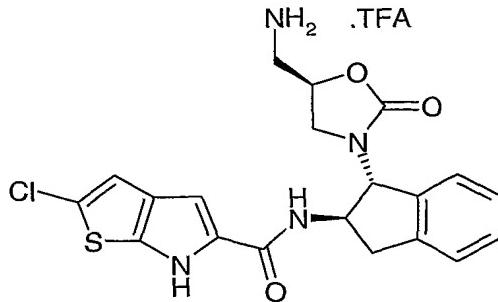
Example 3: 2-Chloro-N-((1*R*,2*R*)-1-{(5*S*)-5-[(methylsulfonyl)methyl]-2-oxo-1,3-oxazolidin-3-yl}-2,3-dihydro-1*H*-inden-2-yl)-6*H*-thieno[2,3-*b*]pyrrole-5-carboxamide



¹⁵ 2-Chloro-N-((1*R*,2*R*)-1-{(5*S*)-5-[(methylthio)methyl]-2-oxo-1,3-oxazolidin-3-yl}-2,3-dihydro-1*H*-inden-2-yl)-6*H*-thieno[2,3-*b*]pyrrole-5-carboxamide (**Intermediate 11**; 90 mg, 0.2 mmol) and *m*-CPBA (100 mg, ~70% purity, ~0.6 mmol) were dissolved in THF (2 mL) and the reaction stirred at ambient temperature for 16 h. The volatiles were removed under reduced pressure and the crude dissolved in EtOAc (20 mL). The organic phase was washed with saturated aqueous sodium bicarbonate solution (20 mL), water (20 mL) and brine (20 mL). The organic phase was dried (MgSO_4) and the volatiles removed under reduced pressure. Purification by flash column chromatography (SiO_2 , 1:1 EtOAc:isohexane to 2:1 EtOAc:isohexane) afforded the title compound (70 mg, 70%) as a solid.

²⁰ ^1H NMR (CDCl_3) δ : 2.95 (s, 3H), 3.20 (dd, 1H), 3.36 (dd, 1H), 3.68 (m, 3H), 4.88 (m, 1H), 5.11 (m, 1H), 5.44 (d, 1H), 6.72 (s, 1H), 6.81 (s, 1H), 6.85 (d, 1H), 7.08 (d, 1H), 7.25 (m, 3H), 10.58 (s, 1H); MS m/z 492 [M-H]⁻.

Example 4: *N*-{(1*R*,2*R*)-1-[*(5R*)-5-(Aminomethyl)-2-oxo-1,3-oxazolidin-3-yl]-2,3-dihydro-1*H*-inden-2-yl}-2-chloro-6*H*-thieno[2,3-*b*]pyrrole-5-carboxamide trifluoroacetate



[*(5S*)-3-((1*R*,2*R*)-2-{[(2-Chloro-6*H*-thieno[2,3-*b*]pyrrol-5-yl)carbonyl]amino}-2,3-dihydro-

5 1*H*-inden-1-yl)-2-oxo-1,3-oxazolidin-5-yl]methyl methanesulfonate (**Intermediate 12**; 102 mg, 0.2 mmol) and ammonia (1 mL, 2 M in isopropanol, 2 mmol) were dissolved in isopropanol (3 mL) and heated in a microwave reactor at 180 °C for 2 h. The volatiles were removed under reduced pressure and the crude material purified by reverse phase HPLC (Column: Phenomenex, Luna C18(2) 100 A, 150 x 21.2mm; Eluent: 95:5 to 5:95

10 water:acetonitrile gradient (plus 0.2% v/v trifluoroacetic acid)) to afford the title compound (40 mg, 45%) as oil which crystallised on standing.

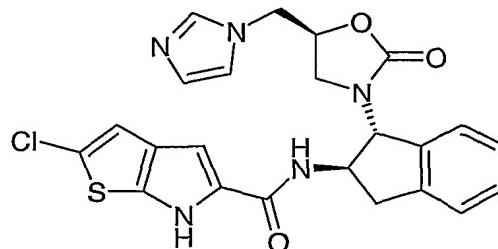
¹H NMR (400 MHz) δ:3.10 (m, 2H), 3.20 (m, 2H), 3.45 (m, 2H), 4.84 (m, 2H), 5.28 (d, 1H), 7.00 (s, 1H), 7.18 (s, 1H), 7.30 (m, 3H), 8.15 (br s, 3H), 8.68 (d, 1H), 11.85 (br s, 1H); MS m/z 431.

15

The following example was made by the process of **Example 4**, using [*(5S*)-3-((1*R*,2*R*)-2-{[(2-Chloro-6*H*-thieno[2,3-*b*]pyrrol-5-yl)carbonyl]amino}-2,3-dihydro-1*H*-inden-1-yl)-2-oxo-1,3-oxazolidin-5-yl]methyl methanesulfonate (**Intermediate 12**) as the mesylate and imidazole as the amine.

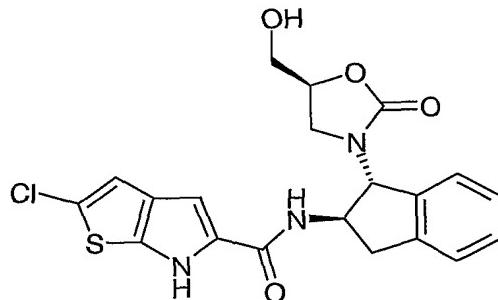
20

Example 5: 2-Chloro-*N*-{(1*R*,2*R*)-1-[*(5R*)-5-(1*H*-imidazol-1-ylmethyl)-2-oxo-1,3-oxazolidin-3-yl]-2,3-dihydro-1*H*-inden-2-yl}-6*H*-thieno[2,3-*b*]pyrrole-5-carboxamide



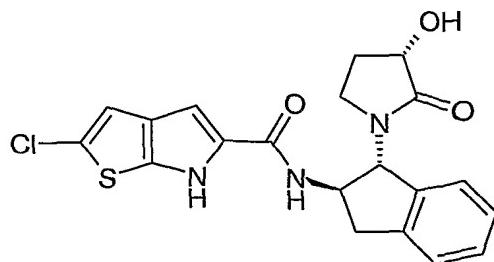
¹H NMR δ: 3.10 (dd, 2H), 3.20 (bb, 2H), 3.52 (m, 2H), 4.56 (m, 2H), 4.85 (m, 1H), 5.05 (m, 1H), 5.27 (d, 1H), 7.04 (s, 1H), 7.19 (m, 2H), 7.27 (m, 3H), 7.70 (s, 1H), 7.80 (s, 1H), 8.68 (d, 1H), 9.17 (s, 1H), 11.85 (br s, 1H); MS m/z 482.

5 **Example 6: 2-Chloro-N-{(1*R*,2*R*)-1-[*(5S*)-5-(hydroxymethyl)-2-oxo-1,3-oxazolidin-3-yl]-2,3-dihydro-1*H*-inden-2-yl}-6*H*-thieno[2,3-*b*]pyrrole-5-carboxamide**



10 4-Nitrobenzyl ((1*R*,2*R*)-2-{[(2-chloro-6*H*-thieno[2,3-*b*]pyrrol-5-yl)carbonyl]amino}-2,3-dihydro-1*H*-inden-1-yl)[*(2S*)-2,3-dihydroxypropyl]carbamate (**Intermediate 13**; 100 mg, 0.17 mmol) was dissolved in DMA (1 mL). Sodium hydride (14 mg, 60% dispersion in mineral oil, 0.34 mmol) was added and the reaction stirred at ambient temperature for 2 h. Water (5 mL) was added and the aqueous phase extracted with EtOAc (2 x 15 mL). The organic phase was washed with water (6 x 20 mL), brine (30 mL), dried (MgSO₄) and the volatiles removed under reduced pressure. The crude material was purified by flash column chromatography (SiO₂, 2:1 EtOAc:isohexane to EtOAc) to afford the title compound (55 mg, 77%) as a solid.
15 ¹H NMR δ: 3.00 (dd, 1H), 3.15 (dd, 1H), 3.30 (m, 2H), 3.50 (m, 2H), 4.54 (m, 1H), 4.75 (m, 1H), 5.00 (t, 1H), 5.27 (d, 1H), 6.99 (s, 1H), 7.15 (s, 2H), 7.25 (m, 3H), 8.56 (d, 1H), 11.85 (br s, 1H); MS m/z 430 [M-H]⁻.

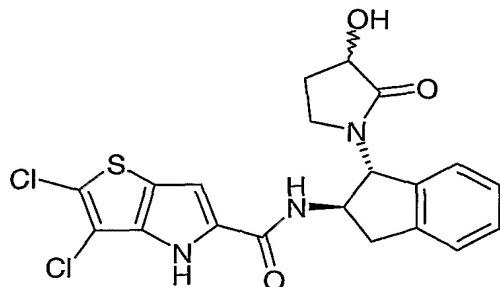
20 **Example 7: 2-Chloro-N-{(1*R*,2*R*)-1-[*(3S*)-3-hydroxy-2-oxopyrrolidin-1-yl]-2,3-dihydro-1*H*-inden-2-yl}-6*H*-thieno[2,3-*b*]pyrrole-5-carboxamide**



(3*S*)-1-[(1*R*,2*R*)-2-Amino-2,3-dihydro-1*H*-inden-1-yl]-3-hydroxypyrrolidin-2-one (**Intermediate 15**; 116 mg, 0.5 mmol), 2-Chloro-6*H*-thieno[2,3-*b*]pyrrole-5-carboxylic acid (**Intermediate 6**; 101 mg, 0.5 mmol), DIPEA (86 uL, 0.5 mmol) and HOBt (68 mg, 0.5 mmol) were dissolved in DMA (2 mL). EDCI (120 mg, 0.63 mmol) was added and the reaction mixture stirred at ambient temperature for 24 h. Water (20 mL) was added and the resulting precipitate was filtered. The crude material was purified by flash column chromatography (SiO₂, eluent: 1:1 isohexane:EtOAc to EtOAc) to afford the title compound (130 mg, 62%) as a white solid.

¹H NMR δ: 1.74 (m, 1H), 2.26 (m, 1H), 3.00 (m, 2H), 3.16 (dd, 1H), 3.34 (dd, 1H), 4.05 (dd, 0.5H), 4.76 (m, 1H), 5.58 (m, 2H), 7.00 (m, 2H), 7.15 (s, 1H), 7.25 (m, 3H), 8.54 (m, 1H), 11.86 (br, 1H); MS m/z 414 [M-H]⁻.

Example 8: 2,3-Dichloro-N-[(1*R*,2*R*)-1-((3*R/S*)-3-hydroxy-2-oxopyrrolidin-1-yl)-2,3-dihydro-1*H*-inden-2-yl]-4*H*-thieno[3,2-*b*]pyrrole-5-carboxamide



15

N-{(1*R*,2*R*)-1-[(2*R/S*)-4-bromo-2-hydroxybutanoyl]amino}-2,3-dihydro-1*H*-inden-2-yl}-2,3-dichloro-4*H*-thieno[3,2-*b*]pyrrole-5-carboxamide (**Intermediate 21**, 720 mg, 1.36 mmol) was dissolved in THF and the solution cooled to 5 °C. NaHMDS (2.7 mL, 1 M in THF, 2.7 mmol) was added dropwise and the solution warmed from 5 °C to ambient temperature and then stirred at ambient temperature for 30 mins. Ammonium chloride (saturated aqueous, 5 mL) and EtOAc (30 mL) were added. The organic phase was washed with water (30 mL) and brine (30 mL), dried (MgSO₄) and the volatiles removed under reduced pressure. The crude material was purified by flash column chromatography (SiO₂, eluent: 1:1 isohexane:EtOAc to 1:4 isohexane:EtOAc) to afford the title compound (420 mg, 68%) as a cream solid.

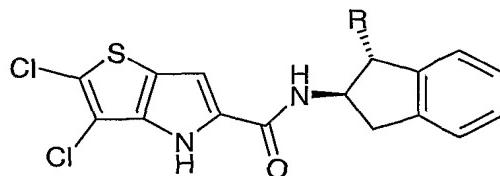
25

¹H NMR δ: 1.70 (m, 1H), 2.26 (m, 1H), 2.97 (m, 2H), 3.18 (m, 1H), 3.35 (m, 1H), 4.07 (m, 0.5H), 4.28 (m, 0.5H), 5.20 (m, 1H), 5.48 (d, 0.5H), 5.55 (m, 1.5H), 7.00 (t, 1H), 7.09 (m, 1H), 7.25 (m, 3H), 8.65 (m, 1H), 12.39 (br s, 1H); MS m/z 448 [M-H]⁻.

The following examples were made by the process of **Example 8**, using *N*-{(1*R*,2*R*)-1-[(2*R*)-4-Bromo-2-hydroxybutanoyl]amino]-2,3-dihydro-1*H*-inden-2-yl}-2,3-dichloro-4*H*-thieno[3,2-*b*]pyrrole-5-carboxamide (**Intermediate 22**) or, *N*-{(1*R*,2*R*)-1-[(2*S*)-4-Bromo-2-hydroxybutanoyl]amino]-2,3-dihydro-1*H*-inden-2-yl}-2,3-dichloro-4*H*-thieno[3,2-*b*]pyrrole-5-carboxamide (**Intermediate 23**) as the alkyl bromide.

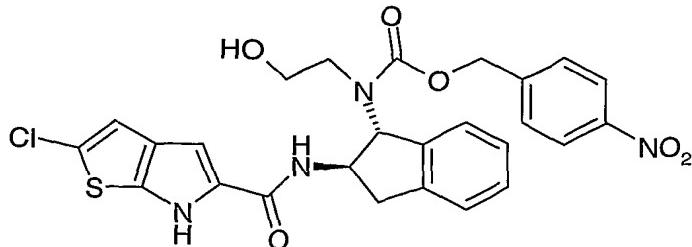
Example 9: 2,3-Dichloro-*N*-(1*R*,2*R*)-1-((3*R*)-3-hydroxy-2-oxopyrrolidin-1-yl)-2,3-dihydro-1*H*-inden-2-yl]-4*H*-thieno[3,2-*b*]pyrrole-5-carboxamide

Example 10: 2,3-Dichloro-*N*-(1*R*,2*R*)-1-((3*S*)-3-hydroxy-2-oxopyrrolidin-1-yl)-2,3-dihydro-1*H*-inden-2-yl]-4*H*-thieno[3,2-*b*]pyrrole-5-carboxamide



Example No	R	¹ H NMR δ	MS m/z
9		1.66 (m, 1H), 2.37 (m, 1H), 2.95 (m, 2H), 3.21 (dd, 1H), 3.39 (t, 1H), 4.27 (m, 1H), 4.85 (m, 1H), 5.49 (d, 1H), 5.57 (d, 1H), 6.99 (d, 1H), 7.10 (s, 1H), 7.25 (m, 3H), 8.67 (m, 1H), 12.39 (br, 1H)	448 [M-H] ⁻
10		1.65 (m, 1H), 2.26 (m, 1H), 3.02 (m, 2H), 3.18 (dd, 1H), 3.37 (dd, 1H), 4.07 (m, 1H), 4.79 (m, 1H), 5.55 (m, 2H), 7.00 (d, 1H), 7.07 (s, 1H), 7.25 (m, 3H), 8.63 (m, 1H), 12.39 (br, 1H)	448 [M-H] ⁻

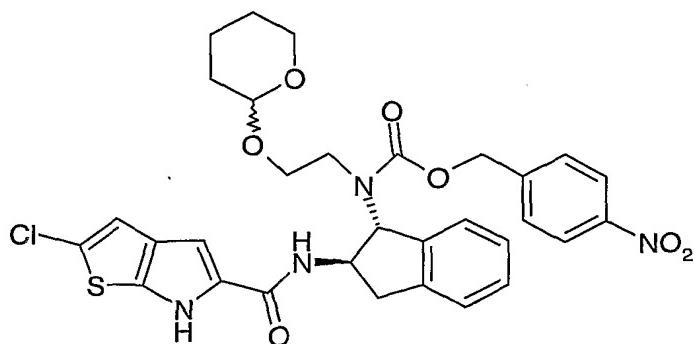
Intermediate 1: 4-Nitrobenzyl ((1R,2R)-2-{[(2-chloro-6H-thieno[2,3-b]pyrrol-5-yl)carbonyl]amino}-2,3-dihydro-1H-inden-1-yl)(2-hydroxyethyl)carbamate



4-Nitrobenzyl ((1R,2R)-2-{[(2-chloro-6H-thieno[2,3-b]pyrrol-5-yl)carbonyl]amino}-2,3-dihydro-1H-inden-1-yl)[2-(tetrahydro-2H-pyran-2-yloxy)ethyl]carbamate (**Intermediate 2**; 530 mg, 0.83 mmol) was dissolved in acetic acid:water (9:1, 10 mL) and heated at 50 °C for 2 h. The volatiles were removed by evaporation under reduced pressure, the residue dissolved in EtOAc (30 mL), washed with saturated aqueous sodium bicarbonate (10 mL), water (10 mL) then brine (10 mL) and dried (MgSO₄). The volatiles were removed by evaporation under reduced pressure and the residue purified by silica gel chromatography (EtOAc:isohexane, 1:1) to give the title compound (250 mg, 54%) as a glass.

MS m/z 553, 555 (M-H).

Intermediate 2: 4-Nitrobenzyl ((1R,2R)-2-{[(2-chloro-6H-thieno[2,3-b]pyrrol-5-yl)carbonyl]amino}-2,3-dihydro-1H-inden-1-yl)[2-(tetrahydro-2H-pyran-2-yloxy)ethyl]carbamate



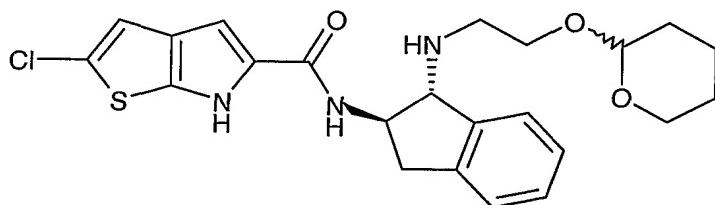
2-chloro-N-((1R,2R)-1-{[2-(tetrahydro-2H-pyran-2-yloxy)ethyl]amino}-2,3-dihydro-1H-inden-2-yl)-6H-thieno[2,3-b]pyrrole-5-carboxamide (**Intermediate 3**; 460 mg, 1.0 mmol) and DIPEA (342 µL, 2.0 mmol) were dissolved in DCM (15 mL), 4-nitrobenzyl chloroformate (236 mg, 1.1 mmol) in DCM (5 mL) added and the reaction stirred at ambient temperature for 20 h. The volatiles were removed by evaporation under reduced pressure, the residue dissolved in EtOAc (40 mL), washed water (10 mL) then brine (10 mL) and dried (MgSO₄).

The volatiles were removed by evaporation under reduced pressure and the residue purified by silica gel chromatography (EtOAc:iso-hexane, 1:1) to give the title compound (530 mg, 83%) as a foam.

MS m/z 637, 639 (M-H).

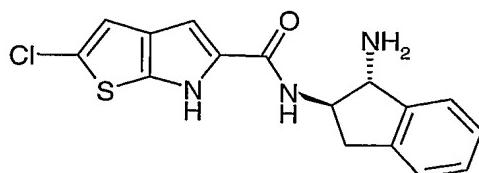
5

Intermediate 3: 2-Chloro-N-[(1R,2R)-1-{[2-(tetrahydro-2H-pyran-2-yloxy)ethyl]amino}-2,3-dihydro-1H-inden-2-yl]-6H-thieno[2,3-b]pyrrole-5-carboxamide



- 10 *N*-[(1*R*,2*R*)-1-Amino-2,3-dihydro-1*H*-inden-2-yl]-2-chloro-6*H*-thieno[2,3-*b*]pyrrole-5-carboxamide trifluoroacetate (**Intermediate 4**; 6.6 g, 20 mmol), 2-(2-iodoethoxy)tetrahydro-2*H*-pyran (5.12 g, 20 mmol) and DIPEA (6.85 mL, 40 mmol) were dissolved in DMA (10 mL) and stirred at 60 °C for 24 h. The reaction was cooled, ethyl acetate (150 mL) added and the mixture washed with water (6x50 mL) then brine (50 mL) and dried over MgSO₄. The volatiles were removed by evaporation under reduced pressure and the residue purified by silica chromatography (EtOAc) to give the title compound (3.65 g, 40%) as a pale brown foam.
- 15 MS m/z 458, 460 (M-H).

Intermediate 4: N-[(1R,2R)-1-Amino-2,3-dihydro-1H-inden-2-yl]-2-chloro-6H-thieno[2,3-b]pyrrole-5-carboxamide

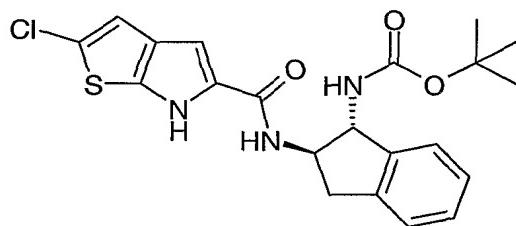


- 20 *tert*-Butyl ((1*R*,2*R*)-2-{{(2-Chloro-6*H*-thieno[2,3-*b*]pyrrol-5-yl)carbonyl}amino}-2,3-dihydro-1*H*-inden-1-yl)carbamate (**Intermediate 5**; 10.6 g, 24.5 mmol) was suspended in DCM (200 mL), TFA (20 mL) added and the reaction stirred at ambient temperature for 20 h. The

volatiles were removed by evaporation under reduced pressure and the residue triturated with DCM (50 mL) then filtered and dried to give the title compound (10.9 g, 100%) as the trifluoroacetic acid salt.

¹H NMR δ: 3.03 (dd, 1H), 3.38 (dd, 1H), 4.7 (m, 2H), 7.06 (d, 1H), 7.17 (s, 1H), 7.35 (m, 3H), 7.55 (m, 1H), 8.55 (s, 3H), 8.68 (d, 1H), 11.9 (s, 1H); MS m/z 315, 317 (M-NH₃).

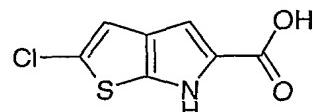
Intermediate 5: *tert*-Butyl ((1*R*,2*R*)-2-{[(2-chloro-6*H*-thieno[2,3-*b*]pyrrol-5-yl)carbonyl]amino}-2,3-dihydro-1*H*-inden-1-yl)carbamate



10 2-Chloro-5-carboxy-6*H*-thieno[3,2-*b*]pyrrole (**Intermediate 6**; 5.0 g, 25.0 mmol), *trans*-2-amino-1-[(1,1-dimethylethoxy)carbonylamino]indan (**Intermediate 8**, 6.25 g, 25.0 mmol), DIPEA (4.35 mL, 25.0 mmol) and HOBr (3.4 g, 25.0 mmol) were dissolved in DCM (200 mL) and stirred for 5 mins. EDCI (6.0 g, 31.0 mmol) was added, the reaction stirred for 24 h and evaporated under reduced pressure. EtOAc (150 mL) was added and the mixture filtered, washed with water (2 x 200 mL), brine (200 mL), dried (MgSO₄) and the volatiles removed by evaporation under reduced pressure to give the title compound (10.6 g, 98%) as a solid.

15 ¹H NMR δ: 1.38 (s, 9H), 2.81 (dd, 1H), 3.17 (dd, 1H), 4.56 (m, 1H), 5.14 (m, 1H), 7.01 (s, 1H), 7.16 (m, 5H), 7.32 (d, 1H), 8.47 (d, 1H), 11.82 (s, 1H).

20 **Intermediate 6: 2-Chloro-6*H*-thieno[2,3-*b*]pyrrole-5-carboxylic acid**



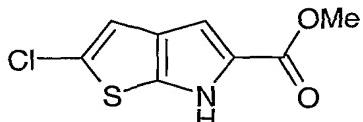
Sodium hydroxide (15 mL, 2N Aqueous) was added to a MeOH (50 mL) solution of 2-chloro-5-methoxycarbonyl-6*H*-thieno[2,3-*b*]pyrrole (**Intermediate 7**, 777 mg, 3.6 mmol) and the mixture heated at reflux for 5 h. The reaction was cooled to ambient temperature, water (250 mL) added and the aqueous phase was washed with Et₂O (2 x 50 mL), acidified to pH 2 with hydrochloric acid (2N) and extracted with EtOAc (3 x 50 mL). The combined organic phases

were washed with water (2 x 50 mL), brine (50 mL), dried (MgSO_4) and the solvent removed under reduced pressure to afford the title compound (705 mg, 97%) as a pale pink solid.

$^1\text{H NMR}$ (CDCl_3) δ : 12.6-12.7 (1H, b), 12.0-12.1 (1H, b), 7.15 (1H, s), 6.9 (1H, s); MS m/z 183, 185.

5

Intermediate 7: 2-Chloro-5-methoxycarbonyl-6*H*-thieno[2,3-*b*]pyrrole

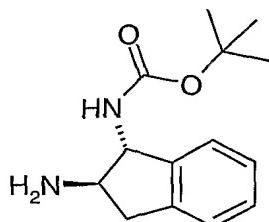


Sodium (659 mg, 28.7 mmol) was added to dry MeOH (20 mL) and the mixture stirred at ambient temperature for 30 mins before cooling to -20 °C. 2-Chlorothiophene-3 –

10 carboxaldehyde (Gronowitz *et al.*, Tetrahedron Vol.32 1976 p.1403; 1.17 g, 7.2 mmol) and methyl azidoacetate (3.3 g, 28.7 mmol) were added as a MeOH (10 mL) solution and the reaction was stirred from -20 °C to 10 °C over 16 h. The reaction was poured on saturated ammonium chloride (300 mL) and extracted with DCM (3 x 100 mL). The combined organic phases were washed with water (2 x 100 mL), brine (100 mL), dried (MgSO_4) and the solvent removed under reduced pressure. The crude product was redissolved in xylene (50 mL) and added dropwise to refluxing xylene (150 mL) and stirred for at reflux for a further 30 mins after the addition was complete. The solvent was removed under reduced pressure to afford a yellow solid which was recrystallised (25:75, EtOAC:isohexane) to afford the title compound (1.06 g, 69%) as a solid.

20 $^1\text{H NMR}$ (CDCl_3) δ : 9.4-9.2 (1H, br), 7.0 (1H, s), 6.9(1H, s), 3.9 (3H, s); MS m/z 214, 216.

Intermediate 8: (1*R*, 2*R*)-Trans-2-Amino-1-[(1,1-dimethylethoxy)carbonylamino]indan



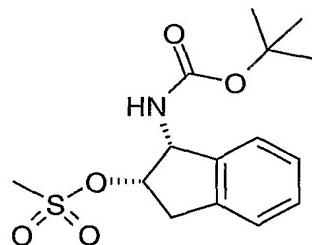
(1*R*, 2*S*)-*Cis*-1-[(1,1-dimethylethoxy)carbonylamino]-2-methanesulphonyloxyindan

25 (Intermediate 9; 18.1 g, 55.3 mmol) was dissolved in dry dimethyl acetamide (100 mL). Sodium azide (5.4 g, 83.0 mmol) was added and the mixture heated to 90 °C for 6 h. The reaction was cooled, diluted with ethyl acetate (150 mL), washed with water (6 x 200 mL)

and dried over magnesium sulphate. 10% Palladium on activated carbon was added and the mixture stirred under a hydrogen atmosphere for 24 h. Filtration through celite followed by evaporation gave the title compound (2.6 g, 98%) as a white solid.

¹H NMR δ: 1.45 (s, 9H), 2.50 (dd, 1H), 3.05 (dd, 1H), 3.30 (m, 3H), 4.55 (m, 1H), 7.1 (m, 5H).

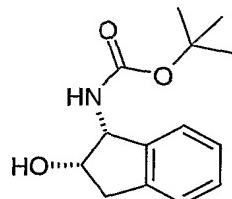
Intermediate 9: (1R, 2S)-Cis-1-[(1,1-dimethylethoxy)carbonylamino]-2-methanesulphonyloxyindan



10 (1R, 2S)-Cis-1-[(1,1-Dimethylethoxy)carbonylamino]-2-hydroxyindan (**Intermediate 10**; 14.0 g, 56.2 mmol) was dissolved in DCM (200 mL) and triethylamine (11.8 mL, 84.3 mmol). Methanesulfonyl chloride (7.1 g, 61.9 mmol) dissolved in DCM (20 mL) was added and the mixture stirred at room temperature for 3 h. The mixture was evaporated and EtOAc (250 mL) added. After washing with water and drying over magnesium sulphate the organic solution was evaporated to afford the title compound (9.7 g, 98%) as a white solid.

15 ¹H NMR δ: 1.45 (s, 9H), 3.15 (m, 2H), 3.18 (s, 3H), 5.20 (m, 1H), 5.35 (m, 1H), 7.15 (m, 4H), 7.45 (d, 1H).

Intermediate 10: (1R, 2S)-Cis-1-[(1,1-Dimethylethoxy)carbonylamino]-2 hydroxyindan



20 (1R, 2S)-Cis-1-Amino-2-hydroxyindan (12.0 g, 80.5 mmol) was dissolved in DCM (500 mL) and triethylamine (22.4 mL, 161 mmol). Di-*tert*-butyl dicarbonate (22.0 g, 100 mmol) in DCM (50 mL) was added and the mixture stirred at room temperature for 20 h then evaporated. EtOAc (200 mL) was added, the solution washed with water, dried over magnesium sulphate and evaporated. The crude product was purified by chromatography on

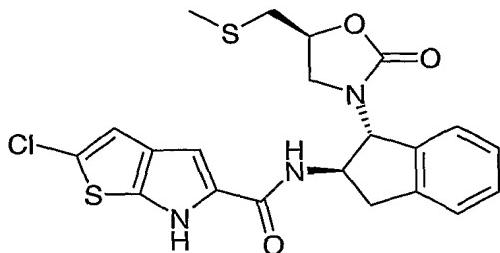
25

silica with 4:1 iso-hexane:EtOAc as eluent to give the title compound (17.9 g, 90%) as a white solid.

¹H NMR δ: 1.42 (s, 9H), 2.78 (dd, 1H), 3.00 (dd, 1H), 4.40 (m, 1H), 4.85 (m, 1H), 4.95 (m, 1H), 6.30 (d, 1H), 7.10 (m, 4H).

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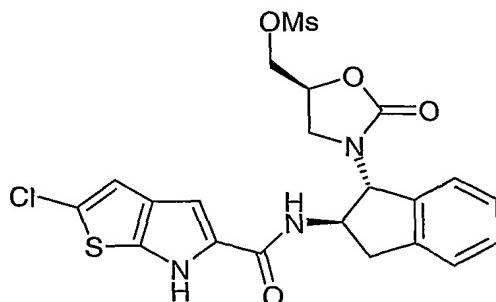
Intermediate 11: 2-Chloro-N-((1*R*,2*R*)-1-[(5*S*)-5-[(methylthio)methyl]-2-oxo-1,3-oxazolidin-3-yl]-2,3-dihydro-1*H*-inden-2-yl)-6*H*-thieno[2,3-*b*]pyrrole-5-carboxamide



[*(5S*)-3-((1*R*,2*R*)-2-{[(2-Chloro-6*H*-thieno[2,3-*b*]pyrrol-5-yl)carbonyl]amino}-2,3-dihydro-1*H*-inden-1-yl)-2-oxo-1,3-oxazolidin-5-yl]methyl methanesulfonate (**Intermediate 12**; 160 mg, 0.31 mmol) and sodium thiomethoxide (88 mg, 1.2 mmol) were dissolved in DMA (2 mL) and stirred at ambient temperature for 17 h. Citric acid (5 mL, 2 N aqueous) and water (10 mL) were added and a precipitate was formed. The precipitate was filtered and dried to afford the title compound (121 mg, 83%) as a solid.

15 MS m/z 460 [M-H]⁻.

Intermediate 12: [(5*S*)-3-((1*R*,2*R*)-2-{[(2-Chloro-6*H*-thieno[2,3-*b*]pyrrol-5-yl)carbonyl]amino}-2,3-dihydro-1*H*-inden-1-yl)-2-oxo-1,3-oxazolidin-5-yl]methyl methanesulfonate



20

2-Chloro-N-((1*R*,2*R*)-1-[(5*S*)-5-(hydroxymethyl)-2-oxo-1,3-oxazolidin-3-yl]-2,3-dihydro-1*H*-inden-2-yl)-6*H*-thieno[2,3-*b*]pyrrole-5-carboxamide (**Example 6**; 216 mg, 0.5 mmol) and triethylamine (139 μL, 1.0 mmol) were dissolved in THF (5 mL) and the solution cooled to 5 °C. Methanesulfonyl chloride (72 mg, 0.63 mmol) was added and the reaction warmed to

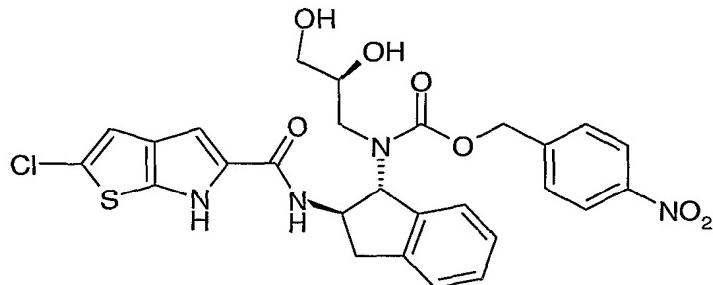
room temperature and stirred at ambient temperature for 2 h. The volatiles were removed under reduced pressure and the crude material dissolved in EtOAc (30 mL). The organic phase was washed with water (50 mL), brine (50 mL), dried (MgSO_4) and the volatiles removed under reduced pressure. Purification by flash column chromatography (SiO_2 , 2:3

- 5 EtOAc:isohexane to 4:1 EtOAc:isohexane) afforded the title compound (180 mg, 70%) as a foam.

^1H NMR δ : 3.03 (dd, 1H), 3.16 (dd, 1H), 3.21 (s, 3H), 3.41 (m, 2H), 4.32 (dd, 1H), 4.45 (dd, 1H), 4.78 (m, 1H), 4.90 (m, 1H), 5.26 (d, 1H), 6.99 (s, 1H), 7.21 (m, 5H), 8.58 (s, 1H), 11.68 (br s, 1H); MS m/z 508 [M-H]⁻.

10

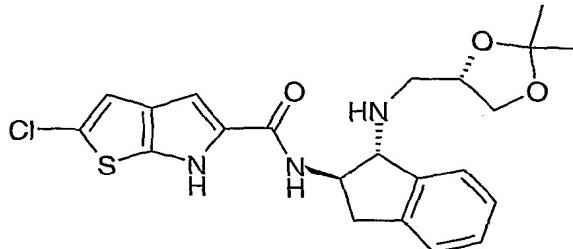
Intermediate 13: 4-Nitrobenzyl ((1*R*,2*R*)-2-{{[(2-chloro-6*H*-thieno[2,3-*b*]pyrrol-5-yl)carbonyl]amino}-2,3-dihydro-1*H*-inden-1-yl)[(2*S*)-2,3-dihydroxypropyl]carbamate



- 2-Chloro-N-[(1*R*,2*R*)-1-({[(4*S*)-2,2-dimethyl-1,3-dioxolan-4-yl]methyl}amino)-2,3-dihydro-1*H*-inden-2-yl]-6*H*-thieno[2,3-*b*]pyrrole-5-carboxamide (**Intermediate 14**; 2.2 g, 4.93 mmol), 4-nitrobenzylchloroformate (1.3 g, 5.92 mmol) and pyridine (798 μL , 9.87 mmol) in DCM (50 mL) were stirred at ambient temperature for 3 h. The volatiles were removed under reduced pressure and the crude material purified by flash column chromatography (SiO_2 , eluant: 2:1 isohexane:EtOAc to EtOAc). The purified carbamate was dissolved in glacial acetic acid (50 mL), water (10 mL) added and the reaction stirred at 45 °C for 2 h. The reaction was cooled to ambient temperature, water (100 mL) added and the resulting precipitate filtered and washed with water (2 x 50 mL) to afford the title compound (3.29 g, 95%) as a yellow powder.
- MS m/z 583 [M-H]⁻.

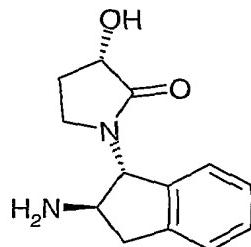
25

Intermediate 14: 2-Chloro-N-[(1*R*,2*R*)-1-({[(4*S*)-2,2-dimethyl-1,3-dioxolan-4-yl]methyl}amino)-2,3-dihydro-1*H*-inden-2-yl]-6*H*-thieno[2,3-*b*]pyrrole-5-carboxamide



5 *N*-[(1*R*,2*R*)-1-Amino-2,3-dihydro-1*H*-inden-2-yl]-2-chloro-6*H*-thieno[2,3-*b*]pyrrole-5-carboxamide hydrochloride salt (**Intermediate 25**; 2.55 g, 7.69 mmol), (2*R*)-2,2-dimethyl-1,3-dioxalone-4-carboxaldehyde (1.0 g, 7.69 mmol) and DIPEA (1.3 mL, 7.69 mmol) were suspended in THF (55 mL). Glacial acetic acid (460 mg, 7.79 mmol) and sodium triacetoxyborohydride (1.63 g, 7.69 mmol) were then added and the reaction was stirred at ambient temperature for 2.5 h. Sodium bicarbonate (saturated aqueous, 100 mL) was added
10 and the aqueous phase extracted with EtOAc (2 x 50 mL). The combined organics were washed with water (100 mL), brine (100 mL), dried (MgSO_4) and the volatiles removed under reduced pressure. The crude material was purified by flash column chromatography (SiO_2 , eluent: 1:1 isohexane:EtOAc to 1:3 isohexane:EtOAc) to afford the title compound (2.25 g, 66%) as a yellow foam.
15 ^1H NMR δ : 1.20 (s, 3H), 1.25 (s, 3H), 2.20 (br s, 1H), 2.75 (m, 3H), 3.22 (dd, 1H), 3.22 (dd, 1H), 3.62 (m, 1H), 3.95 (m, 1H), 4.07 (m, 1H), 4.22 (d, 1H), 4.46 (m, 1H), 7.00 (s, 1H), 7.13 (s, 1H), 7.20 (m, 3H), 7.27 (m, 1H), 8.38 (d, 1H), 11.84 (br, 1H); MS m/z 446.

20 **Intermediate 15: (3*S*)-1-[(1*R*,2*R*)-2-Amino-2,3-dihydro-1*H*-inden-1-yl]-3-hydroxypyrrolidin-2-one**

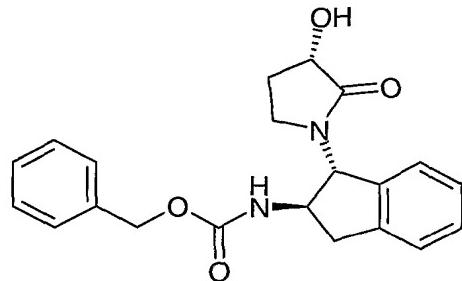


Benzyl {[(1*R*,2*R*)-1-[(3*S*)-3-hydroxy-2-oxopyrrolidin-1-yl]-2,3-dihydro-1*H*-inden-2-yl}carbamate (**Intermediate 16**; 3.4 g, 9.28 mmol) and formic acid (10 mL) were suspended in EtOH (100 mL). 10% Palladium on carbon was added and the reaction mixture was

stirred, under an argon atmosphere, at ambient temperature for 1 h. The reaction mixture was filtered, the volatiles removed under reduced pressure and the crude product co-evaporates with toluene (3 x 75 mL). The crude material was re-dissolved in EtOH:water (60 mL, 5:1) and mesoporous carbonate resin (5 g) added and the suspension stirred at ambient
 5 temperature for 1 h. The suspension was filtered and the volatiles removed under reduced pressure to afford the title compound (1.5 g, 70%).

¹H NMR δ: 1.71 (m, 1H), 2.28 (m, 1H), 2.60 (dd, 1H), 2.87 (t, 1H), 3.02 (dd, 1H), 3.12 (dd, 1H), 3.45 (dd, 1H), 4.22 (t, 1H), 5.08 (s, 2H), 6.92 (d, 1H), 7.15 (m, 3H). MS m/z 233.

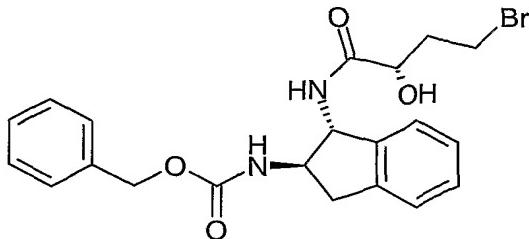
10 **Intermediate 16: Benzyl {((1R,2R)-1-[(3S)-3-hydroxy-2-oxopyrrolidin-1-yl]-2,3-dihydro-
1H-inden-2-yl}carbamate**



Benzyl ((1R,2R)-1-{[(2S)-4-bromo-2-hydroxybutanoyl]amino}-2,3-dihydro-1H-inden-2-yl)carbamate (**Intermediate 17**; 5.0 g, 11.18 mmol) was dissolved in THF (100 mL) and the
 15 solution cooled to 5 °C. NaHMDS (22.4 mL, 1 M in THF, 22.4 mmol) was added dropwise and the solution warmed from 5 °C to ambient temperature and stirred at ambient temperature for 1 h. The reaction was cooled to 5 °C, saturated aqueous ammonium chloride (50 mL) added and the aqueous phase was extracted with EtOAc (3 x 50 mL). The combined organic phase was washed with water (100 mL), brine (100 mL), dried (MgSO₄) and the volatiles
 20 removed under reduced pressure to afford the title compound (3.95 g, 96%).

¹H NMR δ: 1.75 (m, 1H), 2.29 (m, 1H), 2.90 (m, 2H), 3.12 (dd, 1H), 3.35 (m, 1H), 4.1 (dd, 1H), 4.32 (m, 1H), 5.02 (s, 2H), 5.41 (d, 1H), 5.60 (d, 1H), 6.98 (d, 1H), 7.22 (m, 3H), 7.35 (m, 5H), 7.75 (d, 1H).

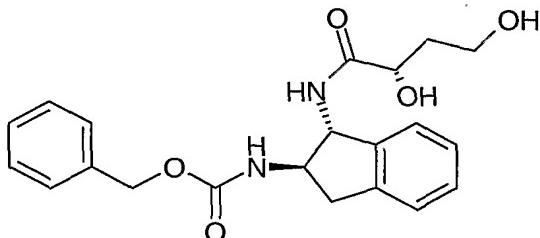
Intermediate 17: Benzyl ((1*R*,2*R*)-1-[(2*S*)-4-bromo-2-hydroxybutanoyl]amino}-2,3-dihydro-1*H*-inden-2-yl)carbamate



Benzyl ((1*R*,2*R*)-1-[(2*S*)-4-bromo-2-hydroxybutanoyl]amino}-2,3-dihydro-1*H*-inden-2-yl)carbamate (**Intermediate 18**; 6.6 g, 17.2 mmol) and carbon tetrabromide (6.26 g, 18.9 mmol) were dissolved in DMA (120 mL). Polymer supported triphenylphosphine (17.2 g, 3 mmol/g polymer loading, 51.5 mmol) was added and the reaction stirred at ambient temperature for 1 h. The reaction was diluted with EtOAc (350 mL) and filtered. The organic phase was washed with water (6 x 100 mL) and brine (200 mL), dried (MgSO_4) and the volatiles removed under reduced pressure. The crude material was flash column chromatography (SiO_2 , eluent: 2:1 isohexane:EtOAc to 1:2 isohexane:EtOAc) to afford the title compound (4.2 g, 55%) as a white solid.

¹H NMR δ : 2.1 (m, 2H), 2.72 (dd, 1H), 3.10 (dd, 1H), 3.51 (dd, 2H), 4.07 (dd, 1H), 4.31 (m, 1H), 5.02 (s, 2H), 5.23 (t, 1H), 7.02 (d, 1H), 7.18 (m, 3H), 7.35 (m, 5H), 7.62 (d, 1H), 8.11 (d, 1H). MS m/z 470 [M+Na]⁺.

Intermediate 18: Benzyl ((1*R*,2*R*)-1-[(2*S*)-2,4-dihydroxybutanoyl]amino}-2,3-dihydro-1*H*-inden-2-yl)carbamate

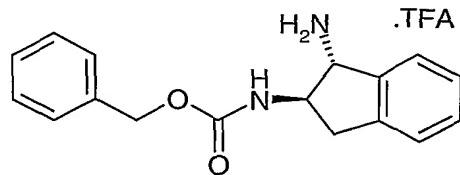


Benzyl [(1*R*,2*R*)-1-amino-2,3-dihydro-1*H*-inden-2-yl]carbamate trifluoroacetate (**Intermediate 19**; 11 g, 21.4 mmol), (3*S*)-3-hydroxydihydrofuran-2(3*H*)-one (6.5 g, 42.8 mmol) and DIPEA were dissolved in 1,4-dioxane (100 mL) and the resulting solution was heated at 100 °C for 24 h. The volatiles were removed under reduced pressure and the crude material was purified by flash column chromatography (SiO_2 , eluent: 1:9, isohexane:EtOAc to EtOAc) to afford the title compound (6.6%, 80%) as a white solid.

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¹H NMR δ: 1.61 (m, 1H), 1.85 (m, 1H), 2.72 (dd, 1H), 3.12 (dd, 1H), 3.51 (m, 1H), 4.05 (m, 1H), 4.30 (m, 1H), 4.40 (t, 1H), 5.02 (s, 2H), 5.25 (t, 1H), 5.37 (d, 1H), 7.02 (d, 1H), 7.18 (m, 3H), 7.35 (m, 5H), 7.62 (d, 1H), 8.00 (d, 1H).

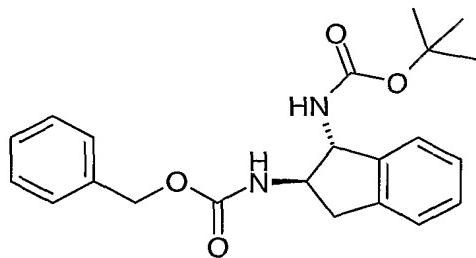
5 **Intermediate 19: Benzyl [(1*R*,2*R*)-1-amino-2,3-dihydro-1*H*-inden-2-yl]carbamate trifluoroacetate**



Benzyl *tert*-butyl (1*R*,2*R*)-2,3-dihydro-1*H*-indene-1,2-diylbiscarbamate (**Intermediate 20**; 8.2 g, 21.44 mmol) was dissolved in DCM (100 mL) and TFA (20 mL) was added and the
10 resulting solution stirred at ambient temperature for 20 h. The volatiles were removed under reduced pressure and the crude product co-evaporated with toluene (2 x 100 mL) to afford the title compound (11 g, 100%) was a pale yellow gum.

MS m/z 283.

15 **Intermediate 20: Benzyl *tert*-butyl (1*R*,2*R*)-2,3-dihydro-1*H*-indene-1,2-diylbiscarbamate**

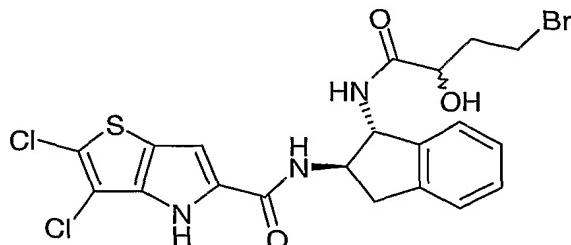


(*1R*, *2R*)-*Trans*-2-Amino-1-[(1,1-dimethylethoxy)carbonylamino]indan (**Intermediate 8**; 7.44 g, 30 mmol) and DIPEA (7.68 mL, 45 mmol) were dissolved in DCM (150 mL) and the solution cooled to 5 °C. Benzyl chloroformate (6.16 mL, 36 mmol) was added dropwise,
20 keeping internal temperature <10 °C. After the addition was complete the reaction mixture was warmed to ambient temperature and stirred for 2 h. The reaction mixture was then washed with citric acid (100 mL), water (2 x 100 mL) and brine (100 mL). The organic phase was dried (MgSO₄), filtered and the volatiles removed under reduced pressure. The resulting solid was then recrystallised from EtOAc:isohexane (2:3, 75 mL) to afford the title
25 compound (8.2 g, 71%) as a cream powder.

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¹H NMR (CDCl₃) δ: 1.50 (s, 9H), 2.71 (dd, 1H), 3.40 (dd, 1H), 4.1 (m, 1H), 4.91 (m, 1H), 5.05 (t, 1H), 5.12 (s, 2H), 5.65 (m, 1H), 7.28 (m, 9H).

5 **Intermediate 21: N-{(1R,2R)-1-[(2R/S)-4-Bromo-2-hydroxybutanoyl]amino}-2,3-dihydro-1H-inden-2-yl}-2,3-dichloro-4H-thieno[3,2-b]pyrrole-5-carboxamide**



10 2,3-Dichloro-N-{(1R,2R)-1-[(2R/S)-2,4-dihydroxybutanoyl]amino}-2,3-dihydro-1H-inden-2-yl}-4H-thieno[3,2-b]pyrrole-5-carboxamide (**Intermediate 24**; 1.65 g, 3.52 mmol), carbon tetrabromide (2.3 g, 7.04 mmol) and polymer supported triphenylphosphine (3.5 g, 3 mmol/g polymer loading, 10.5 mmol) in DMA (20 mL) were stirred at ambient temperature for 2 h.

15 EtOAc (50 mL) was added and the suspension filtered. The organic phase was washed with water (6 x 50 mL), brine (100 mL), dried (MgSO₄) and the volatiles were removed under reduced pressure. The crude product was purified by flash column chromatography (SiO₂, eluant: 2:1 isohexane:EtOAc to 1:2 isohexane:EtOAc) to afford the title compound (1.6 g, 85%) as a white solid.

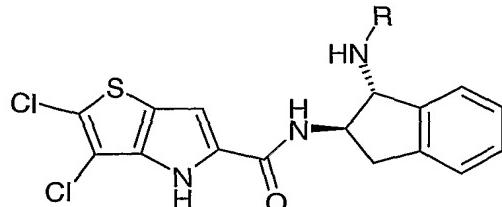
MS m/z 554 [M+Na].

20 The following intermediate were made by the process of **Intermediate 21**, using 2,3-dichloro-N-{(1R,2R)-1-[(2R)-2,4-dihydroxybutanoyl]amino}-2,3-dihydro-1H-inden-2-yl}-4H-thieno[3,2-b]pyrrole-5-carboxamide (**Intermediate 24a**) or 2,3-dichloro-N-{(1R,2R)-1-[(2S)-2,4-dihydroxybutanoyl]amino}-2,3-dihydro-1H-inden-2-yl}-4H-thieno[3,2-b]pyrrole-5-carboxamide (**Intermediate 24b**) as the diol:

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Intermediate 22: N-{(1*R*,2*R*)-1-[(2*R*)-4-Bromo-2-hydroxybutanoyl]amino}-2,3-dihydro-1*H*-inden-2-yl}-2,3-dichloro-4*H*-thieno[3,2-*b*]pyrrole-5-carboxamide

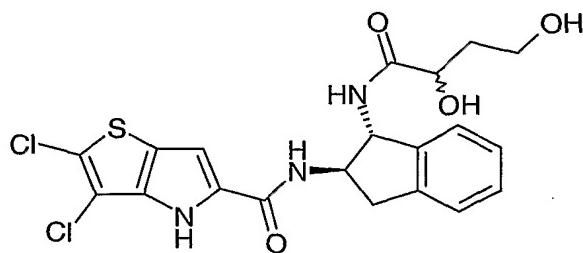
Intermediate 23: N-{(1*R*,2*R*)-1-[(2*S*)-4-Bromo-2-hydroxybutanoyl]amino}-2,3-dihydro-1*H*-inden-2-yl}-2,3-dichloro-4*H*-thieno[3,2-*b*]pyrrole-5-carboxamide



5

Intermediate No	R	MS m/z
22		554 [M+Na] ⁺
23		554 [M+Na] ⁺

Intermediate 24: 2,3-Dichloro-N-{(1*R*,2*R*)-1-[(2*R/S*)-2,4-dihydroxybutanoyl]amino}-2,3-dihydro-1*H*-inden-2-yl}-4*H*-thieno[3,2-*b*]pyrrole-5-carboxamide



10 *N*-[(1*R*,2*R*)-1-Amino-2,3-dihydro-1*H*-inden-2-yl]-2,3-dichloro-4*H*-thieno[3,2-*b*]pyrrole-5-carboxamide (**Intermediate 25a**; 4.0 g, 10 mmol), (3*R/S*)-3-hydroxydihydrofuran-2(3*H*)-one (3.0 g, 30 mmol) and DIPEA (3.5 mL, 20 mmol) in 1,4-dioxane (50 mL) were heated at 100 °C for 24 h. The volatiles were removed under reduced pressure and the crude product was purified by flash column chromatography (SiO₂, eluant: EtOAc) to afford the title compound

15 (2.5 g, 53%) as a brown solid.

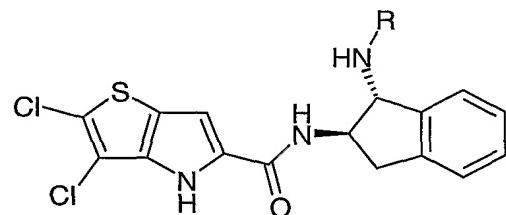
¹H NMR δ: 1.62 (m, 1H), 1.85 (1H, m), 2.85 (m, 1H), 3.22 (m, 1H), 3.50 (m, 2H), 4.02 (m, 1H), 4.36 (dt, 1H), 4.71 (m, 1H), 5.39 (dd, 1H), 5.45 (dd, 1H), 7.06 (2H, m), 7.21 (m, 3H), 8.11 (t, 1H), 8.58 (m, 1H), 12.34 (br s, 1H); MS m/z 466 [M-H]⁻.

The following intermediates were prepared by the method of **Intermediate 24**, using (*3R*) or (*3S*)-3-hydroxydihydrofuran-2(*3H*)-one as the lactones and *N*-[(*1R,2R*)-1-Amino-2,3-dihydro-1*H*-inden-2-yl]-2,3-dichloro-4*H*-thieno[3,2-*b*]pyrrole-5-carboxamide (**Intermediate 25a**) as the amine:

5

Intermediate 24a: 2,3-Dichloro-N-{(1R,2R)-1-[(2R)-2,4-dihydroxybutanoyl]amino}-2,3-dihydro-1*H*-inden-2-yl}-4*H*-thieno[3,2-*b*]pyrrole-5-carboxamide

Intermediate 24b: 2,3-Dichloro-N-{(1R,2R)-1-[(2S)-2,4-dihydroxybutanoyl]amino}-2,3-dihydro-1*H*-inden-2-yl}-4*H*-thieno[3,2-*b*]pyrrole-5-carboxamide

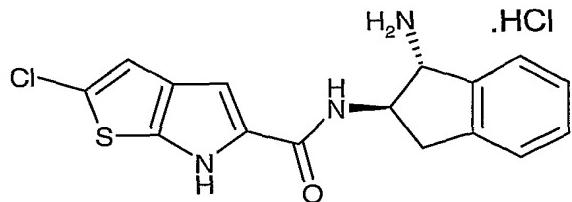


10

Intermediate No	R	¹ H NMR	MS m/z
24a		1.63 (m, 1H), 1.89 (1H, m), 2.82 (dd, 1H), 3.25 (dd, 1H), 3.52 (dd, 2H), 4.00 (m, 1H), 4.40 (t, 1H), 4.72 (m, 1H), 5.40 (d, 1H), 5.45 (t, 1H), 7.05 (2H, m), 7.20 (m, 3H), 8.14 (t, 1H), 8.59 (d, 1H), 12.35 (br s, 1H)	466 [M-H] ⁻
24b		1.58 (m, 1H), 1.81 (1H, m), 2.85 (dd, 1H), 3.23 (dd, 1H), 3.48 (dd, 2H), 4.03 (m, 1H), 4.33 (t, 1H), 4.70 (m, 1H), 5.34 (d, 1H), 5.42 (t, 1H), 7.07 (2H, m), 7.20 (m, 3H), 8.11 (t, 1H), 8.59 (d, 1H), 12.36 (br s, 1H)	466 [M-H] ⁻

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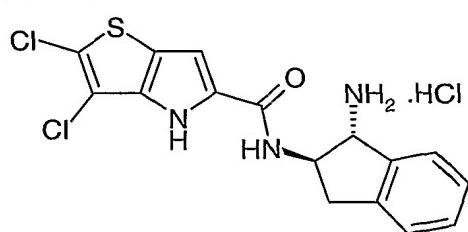
Intermediate 25: N-[(1R,2R)-1-Amino-2,3-dihydro-1H-inden-2-yl]-2-chloro-6H-thieno[2,3-*b*]pyrrole-5-carboxamide hydrochloride salt



- tert-Butyl ((1*R*,2*R*)-2-{[(2-chloro-6*H*-thieno[2,3-*b*]pyrrol-5-yl)carbonyl]amino}-2,3-dihydro-1*H*-inden-1-yl)carbamate (**Intermediate 5**; 3.5 g, 8.1 mmol) was suspended in DCM (10 mL). Hydrochloric acid (20 mL, 4N in dioxane, 80 mmol) was added and reaction stirred at ambient temperature for 48 h. The volatiles were removed under reduced pressure; the resulting solid was azeotroped with EtOAc (4 x 50 mL) and dried *in vacuo* to afford the title compound (2.91 g, 97%) as a brown solid.
- 10 ^1H NMR δ : 3.04 (dd, 1H), 3.87 (dd, 1H), 4.65 (m, 1H), 4.83 (br s, 1H), 7.15 (m, 2H), 7.33 (m, 3H), 7.69 (d, 1H), 8.80 (br s, 3H), 8.96 (d, 1H), 12.00 (s, 1H). m/z 330, 332 [M-H]⁻.

The following intermediate was prepared by the method of **Intermediate 25**, using **Intermediate 24a** as the carbamate

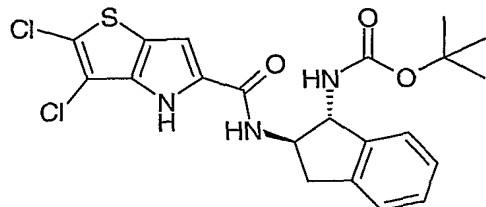
- 15 **Intermediate 25a: N-[(1R,2R)-1-Amino-2,3-dihydro-1H-inden-2-yl]-2,3-dichloro-4H-thieno[3,2-*b*]pyrrole-5-carboxamide**



- 20 ^1H NMR δ : 3.05 (dd, 1H), 3.42 (d, 1H), 4.7 (m, 2H), 7.20(d, 1H), 7.35 (m, 3H), 7.55 (d, 1H), 8.60 (broad s, 3H), 8.80 (d, 1H), 12.5 (broad s, 1H).

The following intermediate was prepared by the method of **Intermediate 5**, using (1*R*, 2*R*)-2-Amino-1-[(1,1-dimethylethoxy)carbonylamino]indan (**Intermediate 8**) as the amine and 5-Carboxy-2,3-dichloro-4*H*-thieno[3,2-*b*]pyrrole (**Intermediate 27**) as the carboxylic acid

Intermediate 26: 2,3-Dichloro-5-(N-[(1*R*,2*R*)-1-*N*-(1,1-dimethylethoxy)carbonylamino]indan-2-yl}carbamoyl)-4*H*-thieno[3,2-*b*]pyrrole

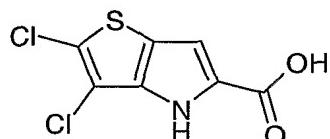


5 5-Carboxy-2,3-dichloro-4*H*-thieno[3,2-*b*]pyrrole (**Intermediate 27**; 2.36g, 10.0mmol), *trans*-2-amino-1-{*N*-[(1,1-dimethylethoxy)carbonylamino]indan (**Intermediate 8**; 2.5g, 10.0mmol), DIPEA (1.7 ml, 10.0mmol) and HOEt (1.35g, 10.0mmol) was stirred in DCM (75 ml) at room temperature for 2 minutes. EDCI (2.4g, 12.5mmol) was added and the mixture stirred at room temperature for 20 hours during which time the product precipitated. The
10 reaction was filtered, washed with DCM (2 x 25 ml) and dried to give the title compound (3.7 g, 80%) as a pale green powder.

¹H NMR δ: 1.40 (s, 9H), 2.81 (dd, 1H), 3.20 (dd, 1H), 4.55 (m, 1H), 5.15 (m, 1H), 7.15 (m, 5H), 7.35 (d, 1H), 8.55 (d, 1H), 12.36 (broad s, 1H); MS m/z 464/466.

The following intermediate was prepared by the method of **Intermediate 6**, using 2,3-Dichloro-5-methoxycarbonyl-4*H*-thieno[3,2-*b*]pyrrole (**Intermediate 28**) as the ester:
15

Intermediate 27: 5-Carboxy-2,3-dichloro-4*H*-thieno[3,2-*b*]pyrrole



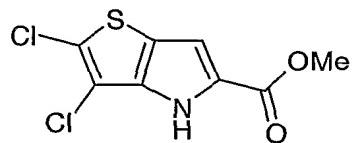
¹H NMR (CDCl₃) δ: 7.0 (1H, s); MS m/z 234.

20

The following intermediate was prepared by the method of **Intermediate 7** using 4,5-dichlorothiophene-2-carbaldehyde (ref: DE 2814798) as the aldehyde:

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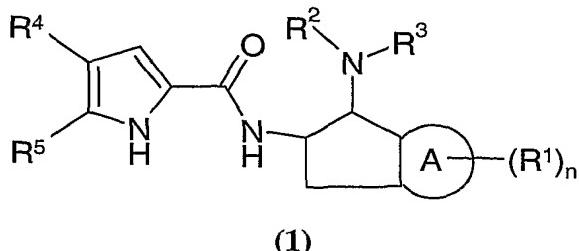
Intermediate 28: 2,3-Dichloro-5-methoxycarbonyl-4H-thieno[3,2-*b*]pyrrole



^1H NMR (CDCl_3) δ : 9.2 (1H, br), 7.0 (1H, s), 3.9 (3H, s); MS m/z 248.2

Claims

1. A compound of formula (1):



5 wherein:

R⁴ and R⁵ together are either -S-C(R⁶)=C(R⁷)- or -C(R⁷)=C(R⁶)-S- ;

R⁶ and R⁷ are independently selected from hydrogen, halo, nitro, cyano, hydroxy, fluoromethyl, difluoromethyl, trifluoromethyl, trifluoromethoxy, carboxy, carbamoyl, (1-4C)alkyl, (2-4C)alkenyl, (2-4C)alkynyl, (1-4C)alkoxy and (1-4C)alkanoyl;

10 A is phenylene or heteroarylene;

n is 0, 1 or 2;

R¹ is independently selected from halo, nitro, cyano, hydroxy, carboxy, carbamoyl, N-(1-4C)alkylcarbamoyl, N,N-((1-4C)alkyl)₂carbamoyl, sulphamoyl, N-(1-4C)alkylsulphamoyl, N,N-((1-4C)alkyl)₂sulphamoyl, -S(O)_b(1-4C)alkyl (wherein b is 0,1,or 2), -OS(O)₂(1-4C)alkyl, (1-4C)alkyl, (2-4C)alkenyl, (2-4C)alkynyl, (1-4C)alkoxy, (1-4C)alkanoyl, (1-4C)alkanoyloxy, hydroxy(1-4C)alkyl, fluoromethyl, difluoromethyl, trifluoromethyl, trifluoromethoxy and -NHSO₂(1-4C)alkyl;

15 or, when n is 2, the two R¹ groups, together with the carbon atoms of A to which they are attached, may form a 4 to 7 membered saturated ring, optionally containing 1 or 2

20 heteroatoms independently selected from O, S and N, and optionally being substituted by one or two methyl groups;

R² and R³ together with the nitrogen to which they are attached form a 4- to 7-membered, saturated, partially unsaturated or unsaturated heterocyclic ring optionally containing 1, 2 or 3 further heteroatoms independently selected from O, N and S (provided that there are no O-O,

25 O-S or S-S bonds), wherein any N, S or C atom may optionally be oxidised, and wherein said heterocyclic ring is optionally substituted with 1 or 2 substituents independently selected from halo, nitro, cyano, hydroxy, fluoromethyl, difluoromethyl, trifluoromethyl, trifluoromethoxy, carboxy, carbamoyl, (1-4C)alkyl, (2-4C)alkenyl, (2-4C)alkynyl,

(1-4C)alkoxy, (1-4C)alkanoyl, -(1-4C)alkylS(O)_b(1-4C)alkyl (wherein b is 1 or 2),

30 hydroxy(1-4C)alkyl, dihydroxy(2-4C)alkyl, amino(1-4C)alkyl, and imidazolylmethyl.

or a pharmaceutically acceptable salt or pro-drug thereof.

2. A compound of formula (1) or a pharmaceutically acceptable salt or pro-drug thereof as claimed in Claim 1 wherein A is phenylene.

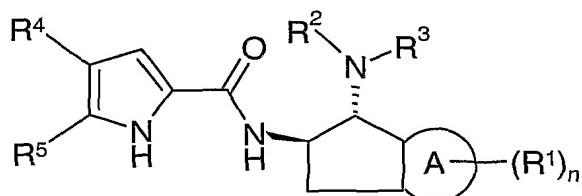
5

3. A compound of formula (1) or a pharmaceutically acceptable salt or pro-drug thereof as claimed in Claim 1 or Claim 2, wherein R² and R³ together with the nitrogen to which they are attached form a 5- or 6-membered ring.

10 4. A compound of formula (1) or a pharmaceutically acceptable salt or pro-drug thereof as claimed in Claim 1, Claim 2 or Claim 3 wherein n is 0.

15 5. A compound of formula (1) or a pharmaceutically acceptable salt or pro-drug thereof as claimed in any one of the preceding claims wherein optional substituents on the ring formed by R² and R³ together with the nitrogen to which they are attached are selected from halo, carboxy, (1-4C)alkyl, (1-4C)alkoxy, hydroxy, amino(1-4C)alkyl, imidazolyl, -(1-4C)alkylS(O)_b(1-4C)alkyl (wherein b is 1 or 2), hydroxy(1-4C)alkyl, and dihydroxy(2-4C)alkyl.

20 6. A compound of formula (1) or a pharmaceutically acceptable salt or pro-drug thereof as claimed in any one of the preceding claims, which is a compound of formula (1A) or a pharmaceutically acceptable salt or pro-drug thereof.



25

(1A)

7. A pharmaceutical composition which comprises a compound of the formula (1), or a pharmaceutically acceptable salt or in-vivo hydrolysable ester thereof, as claimed in claim 1 in association with a pharmaceutically-acceptable diluent or carrier.

30

8. A compound of the formula (1), or a pharmaceutically acceptable salt or in-vivo hydrolysable ester thereof, as claimed in claim 1, for use in a method of treatment of a warm-blooded animal such as man by therapy.

5 9. A compound of the formula (1), or a pharmaceutically acceptable salt or in-vivo hydrolysable ester thereof, as claimed in claim 1, for use as a medicament.

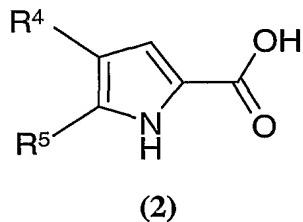
10. A compound of the formula (1), or a pharmaceutically acceptable salt or *in vivo* hydrolysable ester thereof, as claimed in claim 1, for use as a medicament in the treatment of 10 type 2 diabetes, insulin resistance, syndrome X, hyperinsulinaemia, hyperglucagonaemia, cardiac ischaemia or obesity in a warm-blooded animal such as man.

11. The use of a compound of the formula (1), or a pharmaceutically acceptable salt or *in vivo* hydrolysable ester thereof, as claimed in claim 1, in the manufacture of a medicament for 15 use in the treatment of type 2 diabetes, insulin resistance, syndrome X, hyperinsulinaemia, hyperglucagonaemia, cardiac ischaemia or obesity in a warm-blooded animal such as man.

12. The use of a compound of the formula (1), or a pharmaceutically acceptable salt or *in vivo* hydrolysable ester thereof, as claimed in claim 1, in the manufacture of a medicament for 20 use in the treatment of type 2 diabetes in a warm-blooded animal such as man.

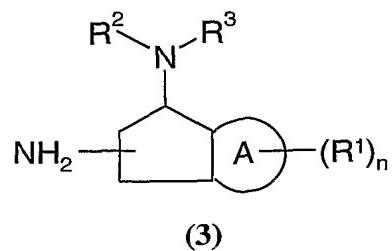
13. A process for the preparation of a compound of formula (1) as claimed in claim 1, which process comprises:

reacting an acid of the formula (2):



or an activated derivative thereof; with an amine of formula (3):

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and thereafter if necessary:

- i) converting a compound of the formula (1) into another compound of the formula (1);
- 5 ii) removing any protecting groups;
- iii) forming a pharmaceutically acceptable salt or in-vivo hydrolysable ester.

INTERNATIONAL SEARCH REPORT

International Application No

GB2004/003622

A. CLASSIFICATION OF SUBJECT MATTER
 IPC 7 A61K31/407 C07D495/04 A61P3/12

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC 7 C07D

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal, WPI Data, BEILSTEIN Data, CHEM ABS Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	WO 02/20530 A (FREEMAN SUE ; KENNY PETER (GB); MORLEY ANDREW (GB); WHITTAMORE PAUL (G) 14 March 2002 (2002-03-14) page 36, line 25 – page 39, line 30; examples 112,133-140,142,148-154 ----- EP 1 136 071 A (PFIZER PROD INC) 26 September 2001 (2001-09-26) the whole document -----	1-13
A		1-13

Further documents are listed in the continuation of box C.

Patent family members are listed in annex.

° Special categories of cited documents :

- *A* document defining the general state of the art which is not considered to be of particular relevance
- *E* earlier document but published on or after the international filing date
- *L* document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
- *O* document referring to an oral disclosure, use, exhibition or other means
- *P* document published prior to the international filing date but later than the priority date claimed

- *T* later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
- *X* document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
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- *&* document member of the same patent family

Date of the actual completion of the international search

12 October 2004

Date of mailing of the international search report

25/10/2004

Name and mailing address of the ISA

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Authorized officer

Gavriliu, D

INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No

PCT/GB2004/003622

Patent document cited in search report	Publication date	Patent family member(s)		Publication date
WO 0220530	A 14-03-2002	AT AU BG BR CA CN CZ DE DK EP HU JP NO NZ PT WO SI SK US	263772 T 8283301 A 107624 A 0113606 A 2417594 A1 1473163 T 20030616 A3 60102710 D1 1317459 T3 1317459 A1 0400784 A2 2004508376 T 20031024 A 524011 A 1317459 T 0220530 A1 1317459 T1 2592003 A3 2003232875 A1	15-04-2004 22-03-2002 30-01-2004 24-06-2003 14-03-2002 04-02-2004 14-05-2003 13-05-2004 12-07-2004 11-06-2003 28-07-2004 18-03-2004 05-03-2003 27-08-2004 31-08-2004 14-03-2002 31-08-2004 05-08-2003 18-12-2003
EP 1136071	A 26-09-2001	AU CA EP HU JP NZ US ZA	2813001 A 2341344 A1 1136071 A2 0101158 A2 2001302546 A 510677 A 2003004162 A1 200102318 A	27-09-2001 22-09-2001 26-09-2001 28-02-2002 31-10-2001 25-10-2002 02-01-2003 20-09-2002

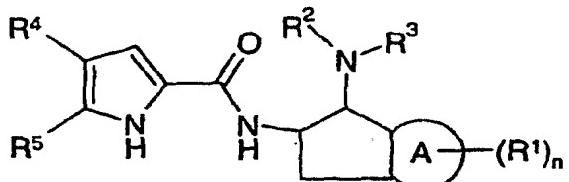
INTERNATIONAL SEARCH REPORT

International application No.

PCT/GB2004/003622

Box No. IV Text of the abstract (Continuation of item 5 of the first sheet)

A compound of the formula (1) or a pharmaceutically-acceptable salt~~or pro-drug~~ thereof;



(1)

wherein:

R^4 and R^5 together are either $-S-C(R^6)=C(R^7)-$ or $-C(R^7)=C(R^6)-S-$;

~~R^6 and R^7 are for example selected from hydrogen and halo~~

A is phenylene or heteroarylene;

~~n is 0, 1 or 2~~

R^1 is for example selected from halo, nitro, cyano, hydroxy, carboxy, carbamoyl, $N-(1-4C)$ alkylcarbamoyl, $N-(1-4C)$ alkylsulphamoyl, (1-4C)alkyl, (1-4C)alkoxy, (1-4C)alkanoyl, (1-4C)alkanoyloxy, hydroxy(1-4C)alkyl, fluoromethyl, and $-NHSO_2(1-4C)$ alkyl;

or, when n is 2, the two R^1 groups, together with the carbon atoms of A to which they are attached, may form a 4 to 7 membered saturated ring, optionally containing 1 or 2 heteroatoms independently selected from O, S and N;

R^2 and R^3 together with the nitrogen to which they are attached form an optionally substituted 4- to 7-membered, heterocyclic ring;

possess glycogen phosphorylase inhibitory activity and accordingly have value in the treatment of disease states associated with increased glycogen phosphorylase activity.

Processes for the manufacture of compounds and pharmaceutical compositions containing them are described.